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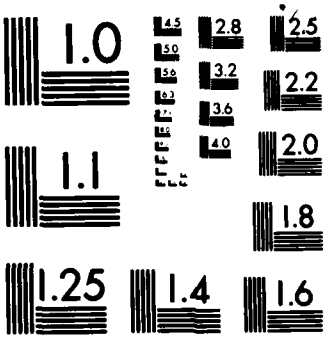

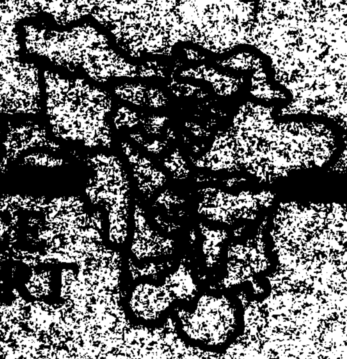

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This report is one of 23 subbasin reports produced by the St. Paul District Corps of Engineers in connection with a reconnaissance report for the whole of the Red River Basin. The reconnaissance report is itself part of the overall Red River of the North study, which was initiated by Congress in 1957 in order to develop solutions for flooding problems within the basin.

The purpose of a reconnaissance study is to provide an overview of the water and related land resource problems and needs within a particular geographic area, to identify planning objectives, to assess potential solutions and

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problems, to determine priorities for immediate and longrange action, and to identify the capabilities of various governmental units for implementing the actions.

The information developed in this report has been combined with information developed in the other subbasin reports to produce a main report covering the basin as a whole. The various flood control measures discussed in this and in other subbasin reports are combined in the main report to develop the outline of an integrated flood control plan for the basin within the context of a comprehensive plan.

The Snake River Subbasin occupies 464 square miles of the northern Minnesota portion of the Red River Basin. It is one of the smaller subbasins, but occupies portions of three counties: Marshall, Polk, and Pennington. It is bordered on the north by the Middle River Subbasin, on the east by the Red Lake River Subbasin, and on the south and west by the Main Stem Subbasin. Since the Middle River to the north is a tributary to the Snake, a small portion of the Snake River Subbasin curves above the Middle River Subbasin. The area has achieved a legal status through the formation of the Middle River-Snake River Watershed District; but, as the name of the District indicates, the Snake River Subbasin is not a separable legal entity.

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RECONNAISSANCE REPORT: RED RIVER OF THE NORTH BASIN, SNAKE RIVER SUBBASIN

Prepared for:

U.S. Army Corps of Engineers
St. Paul District
St. Paul Minnesota

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This report is one of 23 subbasin reports produced by the St. Paul District Corps of Engineers in connection with a reconnaissance report for the whole of the Red River Basin. The reconnaissance report is itself part of the overall Red River of the North Study, which was initiated by Congress in 1957 in order to develop solutions for flooding problems within the basin.

The purpose of a reconnaissance study is to provide an overview of the water and related land resource problems and needs within a particular geographic area, to identify planning objectives, to assess potential solutions and problems, to determine priorities for immediate and long-range action, and to identify the capabilities of various governmental units for implementing the actions.

The Snake River Subbasin is a water resource planning unit located in the northern Minnesota portion of the Red River Basin. This report describes the social, economic, and environmental resources of the subbasin, identifies the water-related problems, needs, and desires, and suggests measures for meeting the needs, particularly in the area of flood control.

The report was prepared almost entirely on the basis of secondary information. However, some telephone contacts were made to verify information and to acquire a more complete picture of local conditions. The only comprehensive report available on the subbasin is the Overall Plan, Middle River-Snake River Watershed District in parts of Marshall, Pennington, and Polk counties, which was published by the Minnesota Water Resources Board in 1972. Other published sources on the subbasin include:

1. Draft, Section 205 Detailed Project Report for Flood Control, Snake River Below Warren, Minnesota, which was published by the St. Paul District Corps of Engineers in 1979 and which identifies and develops a flood damage reduction plan.

2. Application for Assistance in Planning and Carrying Out Works of Improvement Under the Watershed Protection and Flood Prevention Act, Angus-Oslo Watershed, State of Minnesota, which was published by the Marshall County Soil and Water Conservation District in 1971 and is an application for planning assistance submitted to the Soil Conservation Service.

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5. Flood Control Reconnaissance Report, Snake River below Warren, Minnesota, which was published by the St. Paul District Corps of Engineers in 1972 and is a report on an investigation to determine the feasibility of a local flood control project on the Snake River at Warren, Minnesota.

6. Draft Environmental Impact Statement, Snagging and Clearing for Flood Control, Snake River, Minnesota, which was published by the St. Paul District Corps of Engineers in 1979 and deals with the project area below Warren.

In addition, the subbasin received partial coverage in the Souris-Red-Rainy River Basins Comprehensive Study, which was published by the Souris-Red-Rainy River Basins Commission in 1972, and in the Red River of the North Basin Plan of Study, which was published by the St. Paul District Corps of Engineers in 1977.

The information developed in this report has been combined with information developed in the other subbasin reports to produce a main report covering the basin as a whole. The various flood control measures discussed in this and in other subbasin reports are combined in the main report to develop the outline of an integrated flood control plan for the basin within the context of a comprehensive plan.

II. DESCRIPTION OF STUDY AREA

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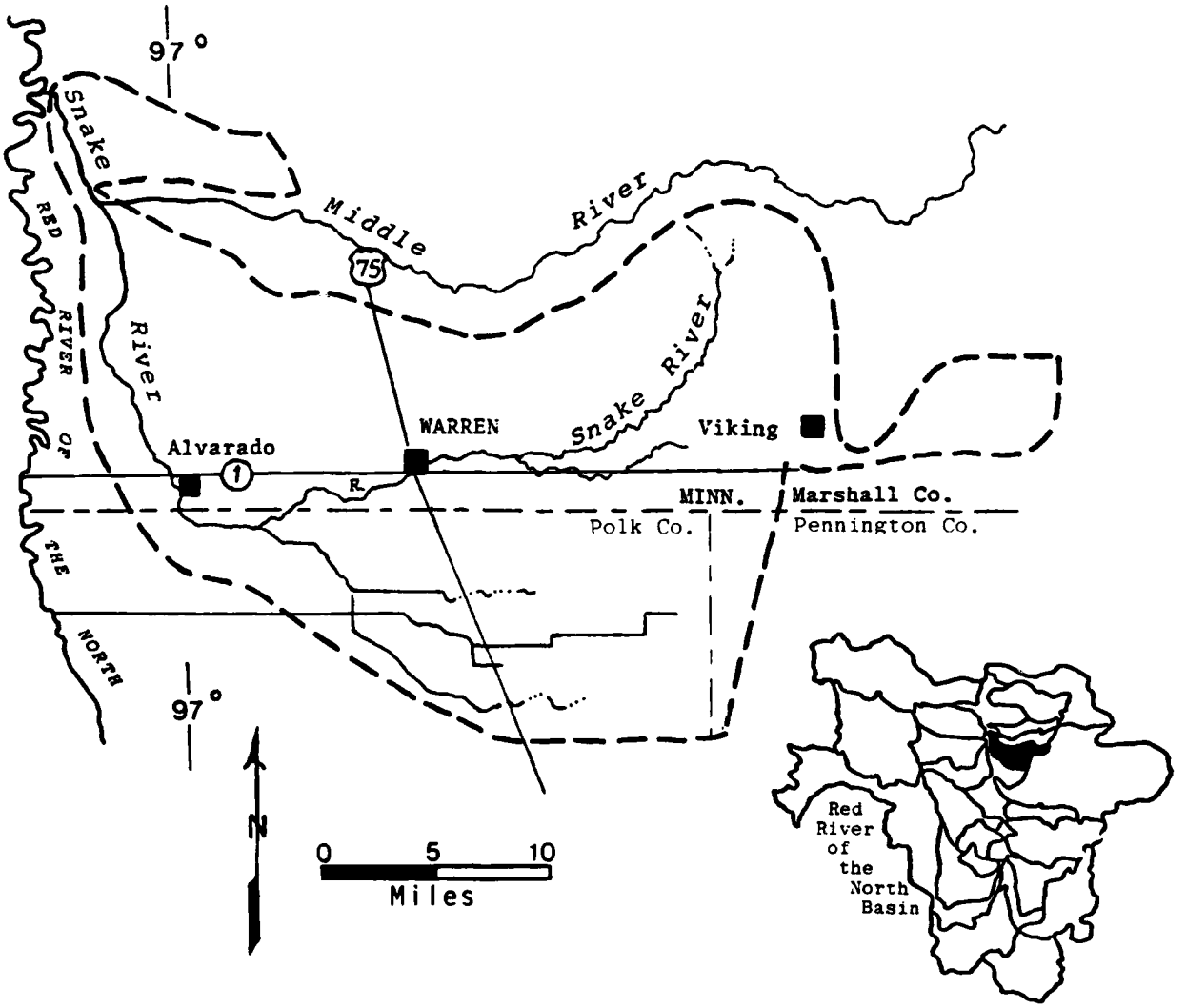
The Snake River Subbasin (Figure I) occupies 464 square miles of the northern Minnesota portion of the Red River Basin. It is one of the smaller subbasins, but occupies portions of three counties: Marshall, Polk, and Pennington. It is bordered on the north by the Middle River Subbasin, on the east by the Red Lake River Subbasin, and on the south and west by the Main Stem Subbasin. Since the Middle River to the north is a tributary to the Snake, a small portion of the Snake River Subbasin curves above the Middle River Subbasin. The area has achieved a legal status through the formation of the Middle River-Snake River Watershed District; but, as the name of the District indicates, the Snake River Subbasin is not a separable legal entity.

Like most of the other subbasins in the Red River Basin, the Snake River Subbasin encompasses three distinct physiographic regions. The central area is composed of sand and gravel beach ridges. To the east, the land is nearly flat, poorly drained, and interspersed with sandy soil and peat bogs. The flat and featureless floor of the Red River Valley extends west of the ridges. The lowest portion of the subbasin is at the mouth of the Snake River, where the ground is about 785 feet above mean sea level. The higher elevations are found in the extreme eastern point, where elevations exceed 1,165 feet. The difference in elevation from east to west is 380 feet.

The Snake River is a slow moving, meandering tributary of the Red River of the North that drains an area of about 486,000 acres and has a total length of about 80 miles. The drainage area at the mouth of the Snake River includes the Middle River drainage area. The river is intermittent, with little or no discharge during most of the year, except for flows caused by runoff from thundershowers or spring snowmelt. The Middle River drains into the Snake River through State Ditch No. 3 about five miles above its mouth.

Regionally, drainage is controlled by the old lake bottom, which slopes to the west but is generally level in the north-south direction. Because of the flatness of the area, the hydrologic conditions that give rise to the subbasin's boundaries are ill defined. To the north, for



Source: Gulf South Research Institute.

Figure I. SNAKE RIVER SUBBASIN

example, it is difficult to distinguish between the drainage areas of the Snake and Middle Rivers; and to the south and west, it is difficult to distinguish between the drainage areas of the Snake River and the Red River of the North. Other drainage features include an extensive system of ditches, most of which run in an east-west direction and are essential for removing water from large tracts of land.

Besides the Snake River and its minor tributaries and connecting ditches, there are no significant water areas in the subbasin. However, there are significant marsh areas in the east, which provide an excellent habitat for wildlife. In addition, there are large tracts of grassland and woodland in the east; but in the west, wooded areas are restricted to the floodplain of the Snake River.

III. PROBLEMS, NEEDS, AND DESIRES

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The primary water-related problems, needs, and desires in the Red River Basin are flood control, fish and wildlife conservation and enhancement, recreation, water supply, water quality, erosion control, irrigation, wastewater management, and hydropower. Various water-related problems, needs, and desires have been identified for the Snake River Subbasin in previous planning reports on the basis of analysis of conditions and public and agency comments. The list of problems, needs, and desires for the subbasin is the same as the list for the Red River Basin as a whole, except for hydropower. Each problem is discussed separately below, with an emphasis on flooding problems.

Flooding Problems

Nature of the Problems

Like other tributaries of the Red River of the North, the Snake River is an intermittent stream with little or no discharge during most of the year except for flows caused by runoff from spring snowmelt and summer thunderstorms. The former is generally more severe than the latter because of snow-filled channels and drainage ditches that retard the generally sluggish flows common to the flat terrain of the Red River Valley.

Depending on physical conditions relating to soils, snow, and/or rainfall, the Snake River is capable of exceeding its banks in a matter of hours and remaining above flood stage for several days. Such floods occur an average of once every two years and often force delays in planting operations which are reflected in reduced crop yields. Also, if water stays on the land too long, it may be impossible to engage in planting operations because of the short growing season.

Besides spring snowmelt flooding, there is also a significant amount of flood damage from high-intensity summer rains. Although they occur less frequently, these summer floods are characterized by high peak flows and, unlike spring floods, can cause extensive damage to maturing crops and even render crop harvest impossible.

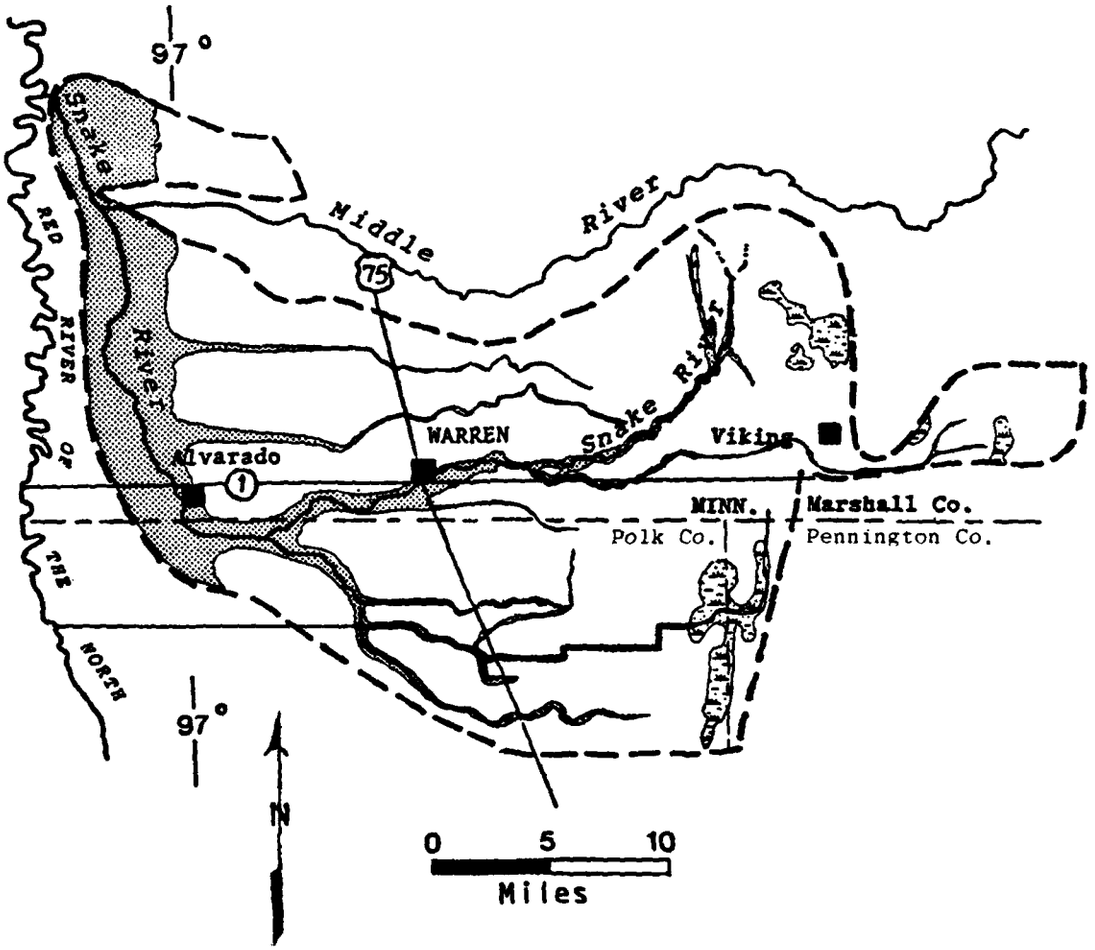
Two separate types of flooding occur: the most damaging type associated with river bank overflow (overbank flooding) and another type caused by runoff from snowmelt or heavy rainfall impounded by plugged culverts and ditches within sections of land bounded by roadways of earthern fill (overland flooding). In overland flooding, the trapped water slowly accumulates until it overflows the roadways and inundates section after section of land as it moves overland in the direction of the regional slope until reaching river or stream channels.

The topography of the subbasin also influences flooding problems. The Snake River rises in the till uplands, an area of gently rolling terrain where the steepest slopes occur. The east central part of the subbasin constitutes the beach ridge area associated with glacial Lake Agassiz. In both of these areas, the channel is fairly well entrenched, thus restricting flood damages. In the flat lake plain of the lower part of the subbasin, however, the gradient drops markedly, and excess waters overtop the river channel, spreading out to inundate thousands of acres of farmland and cause urban damages in Warren and Alvarado.

Flooding conditions within the subbasin are complicated by the fact that peak flows on the Snake River often correlate with peak flows on the Red River and the Middle River. This causes the subbasin flow to back up and inundate large areas in the flat valley plain. Since the subbasin contains about 1.6 percent of the total drainage area of the Red River Basin, runoff from the subbasin does not significantly affect flooding on the Red River.

Location and Extent

Figure II depicts the 100-year floodplain for the Snake River Subbasin. A number of sources were investigated in order to produce the present delineation. Among these were: (1) U.S. Geological Survey (USGS) Flood Prone Area Maps at 1:24,000 scale; (2) Federal Insurance Administration flood maps (various scales); (3) published secondary sources describing flooded areas; and (4) USGS 7 1/2 minute topographic maps. The map is thus a composite of available sources supplemented by inferences where necessary. Because sources were incomplete and based on surveys differing



Source: Gulf South Research Institute

Figure II. 100-YEAR FLOODPLAIN

in purpose and accuracy, it should be understood that Figure II is intended only for general planning purposes. A more complete description of sources and limitations is given in Appendix A.

The initial delineation of the Snake River floodplain depicted in Figure II totals approximately 60,000 acres, with another 10,000 acres in associated marsh in the upper end. Major components include: the lower Snake River paralleling the Red River (38,000 acres), the middle and upper reaches of the Snake River (12,000 acres), two east-west ditches north of State Highway 1 (4,000 acres), and a ditch-tributary system in Polk County (6,000 acres).

The total figure seems reasonable when compared to secondary source acreages. For example, the Middle River-Snake River Overall Plan lists 29,300 acres as flooded in the downstream floodplain (when Middle River segments are subtracted out) in addition to the area adjacent to the Red River. When the 38,000 acres associated with Red River flooding (Figure II) are added to the Overall Plan figure for the comparable middle segment of the Snake, 67,300 acres result. When associated marsh along the middle and upper Snake (4,000 acres) and the aforementioned ditch-tributary system (6,000 acres) is added, 67,300 acres for the lower and middle portions of the subbasin compares favorably with the 70,000-acre total.

The eastern half of the subbasin, composed mainly of beach ridges, includes approximately 10,000 acres of associated marsh, mostly in the extreme upper end of the subbasin. Apart from the marshes, floodplains in this area are narrow, well-defined, and generally limited in extent.

The western half of the subbasin (particularly below Warren) occupies the flat valley plain. Floodplains in this area are not as well defined, and floodwaters spread overland to inundate adjacent farmlands. The Snake River floodplain below Warren is approximately one mile in width. At the point where Snake River turns northward, the width increases to some eight miles (Figure II).

Flood Damages

The primary areas affected by flooding throughout the subbasin's floodplain are urban, agricultural and environmental in nature. Warren

and Alvarado are the two urban areas located in the floodplain. The only damage categories taken into account in the computation of average annual damages are urban and rural.

Present average annual damages in the subbasin are estimated at $404,000. This is a very small figure in that it accounts for less than one percent of the Red River of the North basinwide average annual flood damage total. Average annual flood damages are divided into two basic classifications: urban and rural. Urban damages include damages to residences, businesses (commercial and industrial) and public facilities (streets, utilities, sewers, etc.). Rural damages include damages to crops, other agricultural assets (fences, machinery, farm buildings, etc.) and transportation facilities. Rural damages account for 89 percent of the total average annual damage figure for the subbasin, and urban damages account for the remaining 11 percent.

Urban damages sustained in the flood event of 1975 amounted to $104,200. The 1979 flood event resulted in $140,000 in urban damages, and average annual urban flood damages are estimated at $72,100. A more detailed breakdown of these urban flood damage figures is presented in Table 1. Urban damages resulting from the 1975 flood event included $52,100 in residential damages, $41,700 in damages to businesses, and $10,400 in public damages. In comparison, the 1979 flood event included $70,000 in residential damages, $56,000 in damages to businesses and $14,000 in damages to public facilities. Average annual urban flood damages included $47,800 in residential damages, $15,900 in business damages, and $8,400 in public damages.

Average annual rural flood damages along with the rural flood damages sustained in the flood events of 1975 and 1979 are shown in Table 2. Rural flood damages incurred in both the 1975 and 1979 flood events far exceeded the average annual damages in the subbasin. Rural flood damages sustained in the 1975 flood event included $3.3 million in crop damages, $1.7 million in other agricultural damages, and $68,300 in transportation damages. The 1979 flood event resulted in rural flood damages that included $940,000 in crop damages, $210,000 in other agricultural damages, and

Table 1

SNAKE RIVER SUBBASIN, ESTIMATED 1975,1979,
AND AVERAGE ANNUAL URBAN FLOOD DAMAGES

(Thousands of 1979 Dollars)

	Year		
Category	1975	1979	Average Annual
Residential	$ 52.1	$ 70.0	$47.8
Business	41.7	56.0	15.9
Public	10.4	14.0	8.4
TOTAL	$104.2	$140.0	$72.1

Sources: Section 205, Detailed Project Report for Flood Control, Snake River below Warren, Minnesota, July, 1979; Post Flood Reports, 1975, 1979; and Gulf South Research Institute.

Table 2

SNAKE RIVER SUBBASIN, ESTIMATED 1975, 1979, AND AVERAGE
ANNUAL RURAL FLOOD DAMAGES

(Thousands of 1979 Dollars)

	Year		
Category	1975	1979	Average Annual
Crop	$3,293.6	$ 940.0	$270.1
Other Agricultural	1,721.6	210.0	54.0
Transportation	68.3	170.0	7.8
TOTAL	$5,083.5	$1,320.0	$331.9

Sources: Section 205, Detailed Project Report for Flood Control, Snake River below Warren, Minnesota, July 1979; Post Flood Reports, 1975, 1979; and Gulf South Research Institute

$170,000 in transportation damages. In comparison, average annual rural flood damages are estimated at $270,100 in crop damages, $54,000 in other agricultural damages, and $7,800 in transportation damages. Total rural flood damages were $5.1 million in 1975, $1.3 million in 1979, and $331,900 on an average annual basis.

A point worth mentioning is the difference in average annual flood damages reported in the Red River of the North Basin Plan of Study (April, 1977) and the Section 205 Detailed Project Report for Flood Control, Snake River Below Warren, Minnesota (July, 1979). Average annual urban and rural flood damages for the subbasin taken from the Basin Plan of Study were $28,100 and $250,700, respectively (updated to October 1979 dollars). The Detailed Project Report indicated average annual urban and rural flood damages of $72,100 and $331,900, respectively. Analysis and evaluation of all proposed flood control alternatives (especially urban-related) are based on the figures reported in the Basin Plan of Study unless more current information is available. The Detailed Project Report figures suggest that the average annual damages reported in the Basin Plan of Study may have been understated.

Environmental Concerns

Most of the native prairie and wetlands in the subbasin have been cleared for agricultural production, particularly in the western portion. Woodlands have also been eliminated to a large extent and are now confined mainly to the Snake River floodplain in the west and to the area from Radium east to the headwaters. Data from the Minnesota Land Management Information Service (MLMIS) show that about 90 percent of the total subbasin area is in cultivated, urban residential, pasture and open, urban nonresidential, and transportation land uses (these are habitats of poor or nonexistent quality for biota). The riparian forest is prime habitat for many migratory and resident wildlife and serves an important function as a travel corridor for deer, some moose, and many other species moving from habitats in the eastern portion of the subbasin to those along the Red River. Thus, there is a need to conserve, protect, and enhance wildlife habitats in the subbasin, especially in the riparian woodlands along the Snake River

in the western part. As an example of this need, the Minnesota Department of Natural Resources has acquired a 100-acre tract of bottomland hardwoods upstream of Alvarado as a wildlife management area. The tract is considered unique because it is one of the last substantial stands of timber along a stream in the intensely cultivated Red River Valley, and it also provides some of the best wildlife habitat within an eight-mile radius (U.S. Army Corps of Engineers, 1979a; Upper Mississippi River Basin Commission, 1977).

Problems associated with aquatic biota are related to water quality and intermittent stream flows. The river has a considerable waste load, which is thought to originate from municipal sewage discharges, as evidenced by high or excessive levels of BOD, nutrients, and fecal coliforms. Turbidity violations occur frequently, and total suspended solids concentrations are high periodically. Intermittent flows occur occasionally during the summer, and no-flows may occur continuously for several months. These conditions undoubtedly have an effect on aquatic biota such as the fisheries, which is limited to the extent that the Snake River has been classified as a rough fish, forage fish stream (Maclay et al., 1965; Minnesota Pollution Control Agency, 1975; U.S. Fish and Wildlife Service, 1979a). There is a need to improve these conditions, where possible, to provide better quality aquatic habitats for both aquatic organisms and wildlife.

Recreation Problems

Recreation problems in the subbasin are directly related to the lack of large water bodies and the scarcity of forest tracts in the area. Recreational resources are confined mainly to municipal parks and athletic fields. There are only seven recreational sites over fifteen acres in size, including three wildlife management areas, which are located near Alvarado and Viking. The four remaining sites are located in Warren, and the largest of these is a private country club. There are no waterfowl production areas in the subbasin, since most of the wetlands have been drained for agricultural purposes.

Snake River is an intermittent stream with periods of no-flow and does not provide a favorable habitat for fish species. In addition,

municipal effluents discharged into the river and agricultural runoff contribute to pollution and further reduce the recreational potential and aesthetic qualities of the river.

The subbasin is included in the state recreation bureau Region 1 for planning purposes. The 1979 draft SCORP identifies hunting, camping, fishing, swimming, and hiking as recreational needs in this area. It should be noted that the Agassiz National Wildlife Refuge in Marshall County borders the subbasin to the east, and Old Mill State Park, which provides a variety of recreational opportunities, is located in the Middle River Subbasin nearby; however, residents must travel outside the subbasin to fulfill most water-based and water-related recreational needs.

Water Quality Problems

Surface water quality problems in the subbasin, which have been reported by the Upper Mississippi River Basin Commission, include the following: (1) inadequate streamflow during low runoff periods to assimilate wastes and meet minimum streamflow requirements for recreational and environmental uses; and (2) municipal and agricultural pollution. Maclay et al. (1965) presented more detailed information regarding streamflows in the three regions of the subbasin: lake plain area--no flow may occur continuously for periods longer than eight months; shoreline area--no flow may be expected for several months in most years; glacial till upland area--streamflow not present to any extent. The U.S. Fish and Wildlife Service (1979) indicated that intermittent flows occur occasionally during the summer months.

With regard to the pollution aspect mentioned above, the Minnesota Pollution Control Agency (1975) stated that the Snake River has a considerable waste load, possibly originating from municipal sewage discharges. At times, high levels of BOD and nitrates are observed, and very low dissolved oxygen levels occur occasionally. Fecal coliform concentrations have been in violation and are significant because the stream has been classified for whole-body contact recreation. Additionally, the Agency reported that frequent violations occur with turbidity and periodic high total suspended solids, possibly coming from erosion of surrounding farmlands.

Possible sediment sources (those with medium to high potential for contribution) include streambank and drainage ditch erosion and possibly gully and wind erosion that are present in the counties included by the subbasin (Minnesota Pollution Control Agency, 1979).

Groundwater quality problems are associated with excessive concentrations of total dissolved solids (TDS), iron, manganese, chloride, and sulfate. The high TDS levels render the water unsuitable for most domestic uses (Upper Mississippi River Basin Commission, 1977; U.S. Army Corps of Engineers, 1979 a and b; Minnesota Water Resources Board, no date; Minnesota Department of Health, 1977).

Water Supply Problems

Groundwater supply in the subbasin is limited to the upland till in the eastern portion. In the remainder of the subbasin, especially more westerly areas adjacent to the Red River of the North, suitable groundwater supplies are limited and inadequate. Water from most wells in the lake plain contains high dissolved solids and is not suitable for most domestic purposes.

Surface waters seem to be the largest potential source of water for the subbasin. The best potential is offered by the Red River of the North because the Snake and Middle rivers are intermittent. Adequate storage would be required for these two rivers to be utilized. Storage potential is available from small reservoirs, but large storage capacities are limited by the capacity of the channel at possible reservoir sites and high evaporation losses.

Erosion Problems

Land in the subbasin is susceptible to many kinds of soil erosion. Sheet erosion occurs as uncontrolled flood waters move across cropland and remove topsoil. Quantities of topsoil are lost by sheet erosion, especially in the western portion. Both sheet erosion and wind erosion result in soil deposits in lakes, streams, and drainage systems, causing improper functioning and increased flood problems. Channel erosion of existing drainage systems is prevalent throughout the subbasin and in some sections is quite severe, since the drainage systems are overtaxed.

Soil erosion problems include gullying, which is caused when the Snake River and other waterways leave their banks and gouge new channels across cropland.

Irrigation

Irrigation practices in Minnesota have been increasing steadily since the mid-1930's. Many farmers whose lands have proper soil and water conditions invest in an irrigation system in order to provide more efficient crop production. The amount of irrigated acreage in the subbasin was minimal in 1970. Only a few acres in Pennington County (335) were actually irrigated at that time (Northwest Regional Development Commission, 1978). In 1971, very small amounts of land in Polk (60) and Marshall (80) counties were irrigated. By 1975, the total amount of land being irrigated in the three counties was 8,271 acres, which was an extremely large increase over 1970.

Although irrigation has been increasing, the subbasin's soils are only moderately suited to irrigation activities. In addition, during years when farm incomes decrease, the farmer will be less likely to invest in irrigation equipment. Since severe flooding occurs in some areas and adversely affects farm income, irrigated acreage in the subbasin may not increase dramatically until after the flooding problems are solved.

Wastewater Management

There are only two point source dischargers in the subbasin: Warren and Alvarado (Table 3). The town of Viking is unsewered, and comprehensive sewer plans indicate that there should be no need to develop a sewer system and waste treatment facility in the foreseeable future. Warren has been operating at over one-half capacity but has not discharged any effluent from its facility since 1970. The facility contains evaporation ponds that are either operating inefficiently or have a serious leakage problem. The pond system at Alvarado is hydraulically overloaded and is discharging an effluent that is far above standards set for total suspended solids. Expanding populations projected for this community establish a need to enlarge present operations; however, they were not on the 1975 Municipal Needs List (MNL), a situation which should be rectified. No industrial discharges are known to occur in the municipal systems of Warren or Alvarado (Minnesota Pollution Control Agency, 1975).

Table 3

PROBLEMS AND TREATMENT NEEDS OF POINT SOURCE DISCHARGERS IN THE SNAKE RIVER SUBBASIN

Discharger Description	Receiving Water	Discussion of Problems	Treatment Needs	Other Planning Considerations
Warren	Snake River via ditch	Ponds may leak	Possibly repair ponds, otherwise none	May have no needs should be inspected for problems
Alvarado	Snake River	Hydraulically overloaded TSS in violation of standards	Expand or replace facilities	Should be placed on MNL

Source: Minnesota Pollution Control Agency, 1975.

Hydropower

There are no hydroelectric plants in the subbasin, and the topography does not lend itself to future development. Most of the future large-scale hydropower developments in Minnesota are expected to occur to the southeast of the Red River Basin, particularly in the Minneapolis-St. Paul area.

Public Perception of Problems and Solutions

The public's perception of problems and solutions in the subbasin are defined even though the Corps of Engineers has not held public meetings in the area. The subbasin has been organized as a watershed district, and several applications for planning assistance under the Watershed Protection and Flood Prevention Act have been submitted.

The Middle River-Snake River Watershed District's Overall Plan, published by the Minnesota Water Resources Board in the early 1970's, and planning assistance applications for the Snake River Watershed, Angus-Oslo Watershed, and Melgard-Swift Coulee, constitute the principal documents used to identify public perceptions. The latter were variously prepared and submitted by the Marshall, Pennington, and West Polk Soil Conservation Districts, the villages of Alvarado and Oslo, the town of Warren, and the Polk County Board of Commissioners.

The primary needs identified for the subbasin are fish and wildlife conservation, improved water supplies, water quality control, and flood control. The Overall Plan includes data on four potential impoundment sites. The applications cite specific flood and sediment damage, erosion and water-use and management problems that require attention.

To date, the only flood protection projects in the subbasin are a levee constructed by the village of Alvarado; snagging and clearing of the lower Snake River initiated by the Watershed District; snagging and clearing by the Corps of 23 miles from the mouth to within 10 miles of Alvarado; and local agricultural and farmstead levees. The public, therefore, can be assumed to have a continuing interest in potential flood protection projects that would prove to be cost feasible.

Additional evidence for interest in flood control measures is contained in public hearings held in East Grand Forks in 1978 and 1979 before subcommittees of the Committee on Public Works and Transportation of the

U.S. House of Representatives. From these documents, it is evident that residents of the Red River Basin consider flood control to be the primary water related need for the area and that they are interested in whatever solutions may be proposed by Federal, state, or local agencies.

IV. DESCRIPTION OF SUBBASIN RESOURCES

IV. DESCRIPTION OF SUBBASIN RESOURCES

This section of the report discusses the primary resource conditions within the subbasin that are water-related and that would be affected by a comprehensive water and related land resources plan centering on flood control measures.

Social Characteristics

During the decades prior to 1970, the subbasin experienced a steady decline in population. The loss in population each decade amounted to nearly 10 percent. The declining population was the result of out-migration due to the lack of job opportunities (especially decreased farm employment) within the subbasin. Between 1970 and 1977, however, the population increased from 5,973 to 6,367, which was a 6.6 percent increase. Population growth in the counties of Marshall and Polk was primarily the result of natural increases. Marshall County had a 2.6 percent increase in population with a net out-migration rate of -0.7 percent. Polk County had a four percent increase, which was due to a natural increase and low net in-migration rate of 1.6 percent. The increase in Pennington County's population was the result of an in-migration rate of 8.3 percent.

The largest city in the subbasin is Warren, which had a 1977 population of 2,035. Warren's population increased by almost two percent between 1970 and 1977. The towns of Viking (175) and Alvarado (369) increased by 48 percent and 22 percent, respectively, during the same years.

The population density for the subbasin increased slightly from 9.5 persons per square mile in 1970 to 10.1 persons per square mile in 1977.

Towns in the subbasin, particularly Warren, function as agricultural service centers and are stable communities. In Marshall County, 81.9 percent of the 1970 residents owned their homes, according to census data. Seventy percent of the population was living in the same residence as in 1965, and 86 percent was living in the same county. Approximately 82 percent of employed persons both worked and resided in Polk County.

Approximately 74.1 percent of Pennington County population and 76.1 percent of the Polk County population owned their homes in 1970. Approximately 50 percent of the Pennington County population and 65 percent of the Polk

County population occupied the same residence as in 1965, with 70 percent and 81 percent living in the same respective county. Most of the population in both counties lives and works in the same county (70 percent in Pennington and 81 percent in Polk).

Almost half of the population in each county in the subbasin is of Norwegian background.

Economic Characteristics

Employment

Employment trends for the subbasin are very similar to those throughout rural Minnesota. During the past two decades, the labor force within the subbasin has steadily declined, and the concentration on agricultural employment has shifted to services, wholesale and retail trade, and manufacturing. Farm employment between 1950 and 1970 declined by more than 65 percent in the subbasin, and total employment decreased by 32 percent in the northern portion (Marshall County) and eight percent in the southern portion (Polk County).

The decline in agricultural employment between 1950 and 1970 was caused primarily by a shift toward greater energy intensive farming practices that require greater capital investment and fewer farm laborers. Substantial decreases in farm employment have only partially been offset by large increases in other employment sectors. This accounts for the overall employment decrease in the subbasin. Between 1970 and 1977, farm employment stabilized and other sectors continued to increase. As a result, the total employment increased from 2,270 to 2,865, which was a 26 percent increase.

Unemployment is greater in the Marshall County portion of the subbasin because opportunities for employment in areas other than agriculture are limited. Polk County includes the urban area of Grand Forks-East Grand Forks, which provides varied employment opportunities to offset decreases in agricultural employment. The unemployment rate in the subbasin decreased from seven percent to six percent during the 1970's because of increases in the services, trade, and manufacturing sectors.

Income

Total personal income for the subbasin increased from $24 million to $60 million between 1969 and 1977 (as expressed in 1979 dollars). Farm income accounts for 87 percent of the total personal income in Marshall County and 64 percent in Polk County. Approximately 80 percent of the total farm income throughout the subbasin is due to the sale of cash grains. Average per capita income during the same years increased from $4,085 to $9,462. The 1977 figure, which is expressed in 1979 dollars, is almost 14 percent above the 1979 average income figure of $8,314 for the whole state. Although there has been an upward trend in both personal and per capita income, fluctuating farm prices are the primary determinants of income changes from year to year. Also, severe flooding can cause sharp declines in income, as in 1975.

Business and Industrial Activity

Agriculture

Agriculture and related services are the major economic activities within the subbasin, and the production of small grains is the primary agricultural activity. Approximately 78 percent (or 314,000 acres) of the subbasin's land area is under cultivation, and pasture lands account for 10.9 percent of the land area. Livestock production is more prevalent in the eastern part of the subbasin where the major pasture lands are located as well as the hay producing lands.

Wheat, which accounts for about 44 percent of the total harvested acreage, is the leading crop in the subbasin. This is followed by barley and sunflowers, which together amount to almost 30 percent of the harvested acres. Other important crops include hay, oats, sugarbeets, and potatoes, which collectively total 26 percent of the harvested acreage. Minor acreages of rye, soybeans, and flax are also grown in the subbasin. The production of sunflowers has increased to the point that it is the third leading crop in the subbasin. This increase is a general trend throughout the Red River Basin. The major crops grown in the subbasin are identified in Table 4.

The western half of the subbasin has fine-textured to moderately coarse soils, and the major crops grown there are small grains, sugarbeets,

Table 4

1978 CROP STATISTICS, SNAKE RIVER SUBBASIN

Crop	Harvested Acres	Yield Per Acre	Total Production
Wheat	115,550	39.4 bushels	4,552,670
Barley	51,020	53.3 bushels	2,719,366
Sunflowers	23,770	1,561 pounds	37,104,970

Source: Gulf South Research Institute.

potatoes, and specialty crops such as sunflowers. The eastern portion of the subbasin contains more gravel beach ridges and is more useful for livestock production. The crops grown in this area are generally connected with livestock production, and hay is more dominant than in the western half of the subbasin.

Crops grown along the floodplain of the Snake River are similar to those grown in the rest of the subbasin. Small grains and sunflowers dominate in the western part of subbasin's floodplain, and hay is a major crop in the eastern portion.

Manufacturing

There are only four small manufacturing establishments located in the subbasin. This is a sparsely-populated, rural subbasin that is primarily dependent on agriculture. Manufacturing is mainly agriculture-related and employs a very small portion of the population. Three of the four manufacturers produce fertilizer, and one is a meat processing plant. According to the Minnesota Department of Economic Development, no new manufacturing developments are planned for the subbasin. Table 5 groups the manufacturers according to their Standard Industrial Code (SIC) numbers.

Table 5

MANUFACTURING ESTABLISHMENTS, SNAKE RIVER SUBBASIN

SIC	Description	Estimated Employment
20	Food and Kindred Products	8
27	Printing and Publishing	20
28	Chemicals and Allied Products	16
TOTAL		44

Source: 1979-80 Minnesota Directory of Manufacturers.

Trade

In 1977, total trade receipts for the subbasin exceeded $64 million (expressed in 1979 dollars). More than 62 percent (or $40.2 million) of the receipts were wholesale trade. Retail trade and selected service receipts were $24.2 million and $2.2 million, respectively, in 1977.

Transportation Network

The major highways in the subbasin include Federal Highways 75 (through Warren) and 59 and State Highway 220, all of which cross the subbasin from north to south. Both Highway 75 and Highway 59 intersect Interstate 94 to the south, which provides fast, efficient access to the Minneapolis-St. Paul area. The two highways also intersect Federal Highway 2, which travels to the port of Duluth. The major east-to-west route is State Highway 1 (through Warren and Alvarado), which intersects Interstate 29 in North Dakota 20 miles to the west and provides access to the Fargo-Moorhead area. Highway 220 is important because it is a direct route from Alvarado to the East Grand Forks-Grand Forks area.

The subbasin is also traversed by the Soo Line Railroad and the Burlington Northern Railroad, which parallel Federal Highways 75 and 59 and State Highway 1. The Soo Line passes through Alvarado, Warren, and Viking, and the Burlington Northern runs through Warren. A natural gas pipeline and a pipeline carrying crude oil cross the extreme western part of the

subbasin in a northwest to southeast direction. Another natural gas pipeline crosses the subbasin from north to south near the town of Warren. The only airport in the subbasin is located in the town of Warren and has a few facilities for light planes.

Highways 220, 1, 75, and 59 are crossed by the Snake River, and so are the railroads. The airport is located near the river in Warren. All of these facilities are subject to flooding.

Land Use

Approximately 78 percent of the subbasin is under cultivation, 10.9 percent is pasture, eight percent is forest, and 1.8 percent is water and marsh. The western half of the subbasin is almost entirely under cultivation, and there are only small patches of trees along the river. The eastern half of the subbasin has more forested areas, less cultivated land, and a few marsh areas. Urban development is minimal.

Land use in the floodplain of the Snake River does not differ significantly from land use throughout the subbasin. The floodplain is an important agricultural area, especially in the western part of the subbasin. In the eastern part of the subbasin, the floodplain is also under cultivation, but there is more forest acreage.

Land use activities in the subbasin have significantly altered the original landscape through wetland drainage, forest clearing, agricultural development, an urban expansion. Most of the remaining forests are near farms or along stream valleys.

Environmental Characteristics

Climate

Active weather stations are located at the communities of Angus and Argyle. The cities of Thief River Falls and Crookston have weather stations which are outside the subbasin but not far away. The climate of the subbasin is characterized by wide variations in temperature, with moderate rainfall and snowfall. The mean annual precipitation averages 19.7 inches, with snow accounting for about 2.6 inches of the total. The mean temperature is 38°F. Extreme temperatures recorded range from a high of 108°F to a low of -49°F. Frost free days, as observed at the University of Minnesota

Experiment Station at Crookston, average 124 days annually. The average date of the last frost in spring is May 19, and the first frost in fall is September 20.

Geology

The subbasin lies within the Western Lake Section in the Central Lowland Province of the Interior Plains. Bedrock is predominantly undifferentiated Precambrian igneous and metamorphic rock separating bands of undifferentiated Ordovician limestone and dolomite in the eastern section of the subbasin. Undifferentiated Cretaceous deposits consisting of generally fine-grained sandstone and areas of interbedded shale overlie Ordovician sediments in the west.

Glacial deposits of clay, loam till, sandy till, sands, and gravels overlie bedrock. The weathering of these materials has contributed to the formation of fertile agricultural soils in the region. Glacial activity in the region has also produced the level land, beach ridge, swamp pattern characteristic of the area.

Biology

The major forest types occurring in the subbasin are elm-ash-cottonwood and aspen-birch. The elm-ash-cottonwood type is found in the floodplain of the Snake River from near its confluence with the Red River to the area south of Radium. From Radium east to the headwaters of the subbasin, the aspen-birch type predominates (North Central Forest Experiment Station and Minnesota State Planning Agency, no date). The U.S. Army Corps of Engineers (1979a,b) indicates that natural vegetation along the river from Warren westward is primarily a riparian community with some native woodlands and planted shelterbelts on farmsteads. Trees consist of boxelder, green ash, and American elm. A shrub layer is generally lacking, and the herbaceous layer, composed mainly of wood nettle, is poorly developed. In the unique, 100-acre woodland tract near Alvarado (previously mentioned in the Problems and Needs discussion), tree species include bur oak, elm, cottonwood, aspen, balm of Gilead, ironwood, ash, boxelder, American plum, and black willow. Back from the river, the existing shrub layer is comprised of chokecherry, raspberry, and dogwood. The aspen-birch community consists of aspen, paper birch, snowberry, mosseberry, and red-osier dogwood (Waneks, 1967).

The subbasin lies within three major wetland zones: Red River Valley Lake Plain, Glacial Lake Agassiz Beachlines, and Aspen Parklands. The Lake Plain zone is found generally from Warren westward in what used to be the bed of Glacial Lake Agassiz. Agricultural development has eliminated nearly all of the shallow wetlands and native prairie that once occupied this region. The Glacial Beachline extends through the area of Radium and through Viking and once contained numerous shallow wetlands. The Aspen Parklands zone is situated in the extreme eastern part of the subbasin, where it forms the dynamic transitional zone between grassland and coniferous formations. It is composed of potholes and shallow marshes interspered with groves of aspen limited by fire and farming (Mann, 1979). Examples of wetland types that possibly occur in these zones include the following: Type 1--seasonally flooded basins and flats, Type 3--shallow fresh marshes, Type 4--deep fresh marshes, Type 5--open fresh marshes, Type 6--shrub swamps, and Type 7--wooded swamps (U.S. Fish and Wildlife Service, 1980).

Important wildlife habitats in the subbasin are any remaining prairie remnants and the wetlands and woodlands. The native grasslands are significant habitats for both flora and fauna and originally occurred in combination with wetland complexes to form a dynamic and diverse ecosystem supporting an abundance of birds, mammals, and invertebrates. Wetlands afford spawning and nursery areas for aquatic vertebrates and invertebrates; breeding, nesting, feeding, and resting areas for waterfowl; breeding and rearing habitat for big and small game, furbearers, and other wildlife; and provide a high-yield food source for many resident species. Woodlands and brushy areas furnish important habitats for feeding, resting, breeding, and nesting; they provide habitat for a greater variety of wildlife species than any other major habitat in the subbasin. As mentioned earlier, the riparian forest along the Snake River is significant as a migration and travel corridor for wildlife moving from the eastern portion of the subbasin to environs along the Red River (U.S. Army Corps of Engineers, 1979a; U.S. Fish and Wildlife Service, 1980).

The white-tailed deer is the major big game animal of the subbasin. Harvest figures for 1978 in the three counties included by the subbasin's limits were as follows: Marshall--778, Polk--463, and Pennington--122.

Wintering yards, with herds of 20-30 animals each, are located near Alvarado and Warren. Some moose also occur and have been observed using the riparian woodlands west of Warren when moving through the extensive farmlands in this region. Small game mammals consist of the jackrabbit and some snowshoe hare, and gray and fox squirrels. Furbearers include the beaver, mink, raccoon, muskrat, and gray and red foxes. Twenty-nine nongame mammals have been reported from the three-county area; common species include the striped skunk, plains pocket gopher, white-footed mouse, and thirteen-lined ground squirrel. The diverse habitats of the subbasin are inhabitated by approximately 140 species of avians. A total of 101 species of breeding birds are known from the region and are composed of the following: non-native pest birds--three species, non-native game birds--one species, native game birds--10 species, and native nongame birds--87 species. Upland game birds consist of some Hungarian partridge, sharp-tailed grouse, and ruffed grouse. Eighteen species of herpetofauna are known from the three counties encompassed by the subbasin and include species such as the northern prairie skink, western plains garter snake, eastern tiger salemander, boreal chorus frog, and common gray treefrog (Henderson, 1978, 1979; Henderson and Reitter, 1979; literature cited in Mann, 1979; U.S. Army Corps of Engineers, 1979a; U.S. Fish and Wildlife Service, 1980).

Because of municipal, industrial, and agricultural effluents, channel improvements, and the infrequent and intermittent flows, the fish resources on the Snake River have been limited. The Minnesota Department of Natural Resources has classified the Snake River as a rough fish, forage fish (Class IV) stream, which means that the fish population is dominated by rough or forage fish such as silver redhorse, northern redhorse, quillback, back, freshwater drum, white sucker, common shiner, and spot-tailed shiner. Game species presumed to occur in the Snake River include channel catfish, walleye, and northern pike. However, the populations of these game species are severly limited (U.S. Fish and Wildlife Service, 1979; U.S. Army Corps of Engineers, 1979a and b).

Only two species of mussels were reported by Cvancara (1970) to inhabit the Snake River. Both of the species, Anodonta grandis and Anodontoides

ferussacianus, were represented by live specimens. Of the 18 tributaries of the Red River that Cvancara sampled, the Snake River had the least number of mussel species.

Water Supply

Small to moderate supplies of groundwater for domestic use are available in most places in the till upland and eastern part of the shoreline area. Small to inadequate supplies of groundwater for domestic purposes occur throughout most of the lake plain and western part of the shoreline area. Groundwater supplies for the small communities in the subbasin are adequate for present rates of use. The largest city in the subbasin, Warren, obtains its water supply from three deep wells. The Minnesota Department of Health reports an approximate annual water usage of 47,450,000 gallons by Warren. Additional amounts of groundwater could be developed for communities by drilling wells at properly spaced intervals within the mapped aquifers. Potential yield from all groundwater sources is small compared to surface water, but groundwater is important for small local supplies.

The Middle River and Snake River are potential sources of water for moderate amounts of usage, but development of water from these intermittent streams requires adequate storage. The Red River of the North is the largest potential source of water for the Snake River subbasin.

Water Quality

Water quality data for the Snake River near Big Woods is given in Table 6. Water uses established for this stream are fisheries and recreation, industrial consumption, agriculture and wildlife, and other uses. The data in Table 6 indicate that turbidity standards are frequently violated--19 percent of the time--and BOD (maximum of 12 mg/l) and nitrates (maximum of 2.8 mg/l) are high at times. The dissolved oxygen parameter exceeded its criterion in eight percent of the samples, with a low of 0.8 mg/l. These low levels will affect game fish populations. Twelve percent of the fecal coliform samples were in violation, which is significant, since these waters have been designated for whole-body contact recreation (Minnesota Pollution Control Agency, 1976). Sources of these problems were outlined in the Problems and Needs discussion.

SURFACE WATER QUALITY DATA FOR THE SN.

Description	Flow (cfs)	Temperature (°F)	D.O. (mg/l)	BOD_5 (mg/l)	NH_3 (mg/l)	Fecal Coliforms (MPN/100 ml)	
Water Quality Standards in this Segment		5° change 2B-85° Maximum	2B*	--	2B-1.0	200	
Monitoring Stations	Average 7-Day 10-Year Low	Average Maximum	Percent of Violation	Average Minimum	Percent of Violation	Average Maximum	Percent of Violation
Lake River SR-1.8		53		7.6		4.6	
Bridge SH-220 near Big Woods	--		-0-		8		--
26 reports 1971-74		75		0.8		12	

Description	Average Maximum	Percent of Violation	Average Maximum	Percent of Violation	Average Maximum
Water Quality Standards in this Segment	2B-1.0		200		
Monitoring Stations	Average	Percent of	Average	Percent of	Average
Lake River SR-1.8	0.16		84		4[illegible]2
Bridge SH-220 near Big Woods		-0-		12	
26 reports 1971-74	0.66		700		

-4/1-5/31 - five other times.

urce: Minnesota Pollution Control Agency, 1975.

Table 6

E SNAKE RIVER NEAR BIG WOODS FROM 1971-74

TDS (mg/l)	pH	Turbidity (JTU)	Oil (mg/l)	NO_3 (mg/l)	Phosphorus (mg/l)	TSS (mg/l)
700	6.5-9.0	25	0.5	45	--	--

Average		Average		Average		Average		Average		Average		Average	
Maximum	Percent of Violation	Range	Percent of Violation	Maximum	Percent of Violation	Maximum	Percent of Violation	Maximum	Percent of Violation	Maximum	Percent of Violation	Maximum	Percent of Violation
412		7.9		26				0.32		0.3		49	
--	--	7.3-	-0-		19	--	--		--		--		--
--		8.9		170				2.8		0.77		350	

Groundwater quality data for the communities of Alvarado, Viking, and Warren are shown in Table 7. These data show that the quality of the groundwater in these towns is hard to very hard and possessess excessive levels of iron. With the exception of Warren, manganese is also present in excessive concentrations. Problems occur with chlorides in Alvarado and Warren, and with sulfate in Alvarado. The only data available for total dissolved solids was from two wells in Warren that showed that levels of this parameter are well above the established criteria of 500 mg/l.

Table 7

GROUNDWATER QUALITY DATA[a] FROM COMMUNITIES IN THE SNAKE RIVER SUBBASIN

Parameter	Criteria[b]	Alvarado				Viking			Warren		
Sample Date		2-61	1965	11-71	11-71	5-73	5-73	1965	11-69	11-69	11-71
Well Depth		161	158	161	161	184	183	110	--	--	--
Total Hardness	--	490	490	510	520	320	330	132	190	160	170
pH	5-9	7.8	7.8	7.4	7.5	7.7	7.7	7.6	7.9	8.0	7.3
Iron	0.3 mg/l	1.0	1.0	0.62	0.02	1.8	1.0	0.68	0.61	0.66	0.33
Manganese	0.05 mg/l	0.16	--	0.24	0.23	0.09	0.09	--	0.02	0.02	0.03
Chloride	250 mg/l	600	600	730	730	27	30	252	460	240	280
Sulfate	250 mg/l	280	--	250	250	170	180	--	110	5	<5
Fluoride	1.5 mg/l	0.64	--	0.7	0.7	--	--	--	0.80	0.81	0.5
Nitrate Nitrogen	45 mg/l	<1	--	2.3	2.3	<1	<1	--	1.8	1.0	<1
Total Dissolved Solids	500 mg/l	--	--	--	--	--	--	--	1,200	760	--

[a] All chemical data expressed in mg/l(ppm).

[b] From Minnesota Department of Pollution Control Agency, 1975 and/or U. S. Environmental Protection Agency, 1976.

Source: Minnesota Department of Health, 1977; Maclay et al., 1965.

Aesthetics

Large water bodies and tracts of forest lands providing diversity of landscape are lacking in the subbasin. Most of the area has been cleared for agricultural purposes; however, the wildlife managment areas and some wooded corridors along the Snake River provide valuable wildlife habitat and provide contrast to the level terrain of the region. The aesthetic appeal of the Snake River has been diminished by the discharge of municipal wastes into the stream and by agricultural runoff, which contributes to pollution.

Cultural Elements

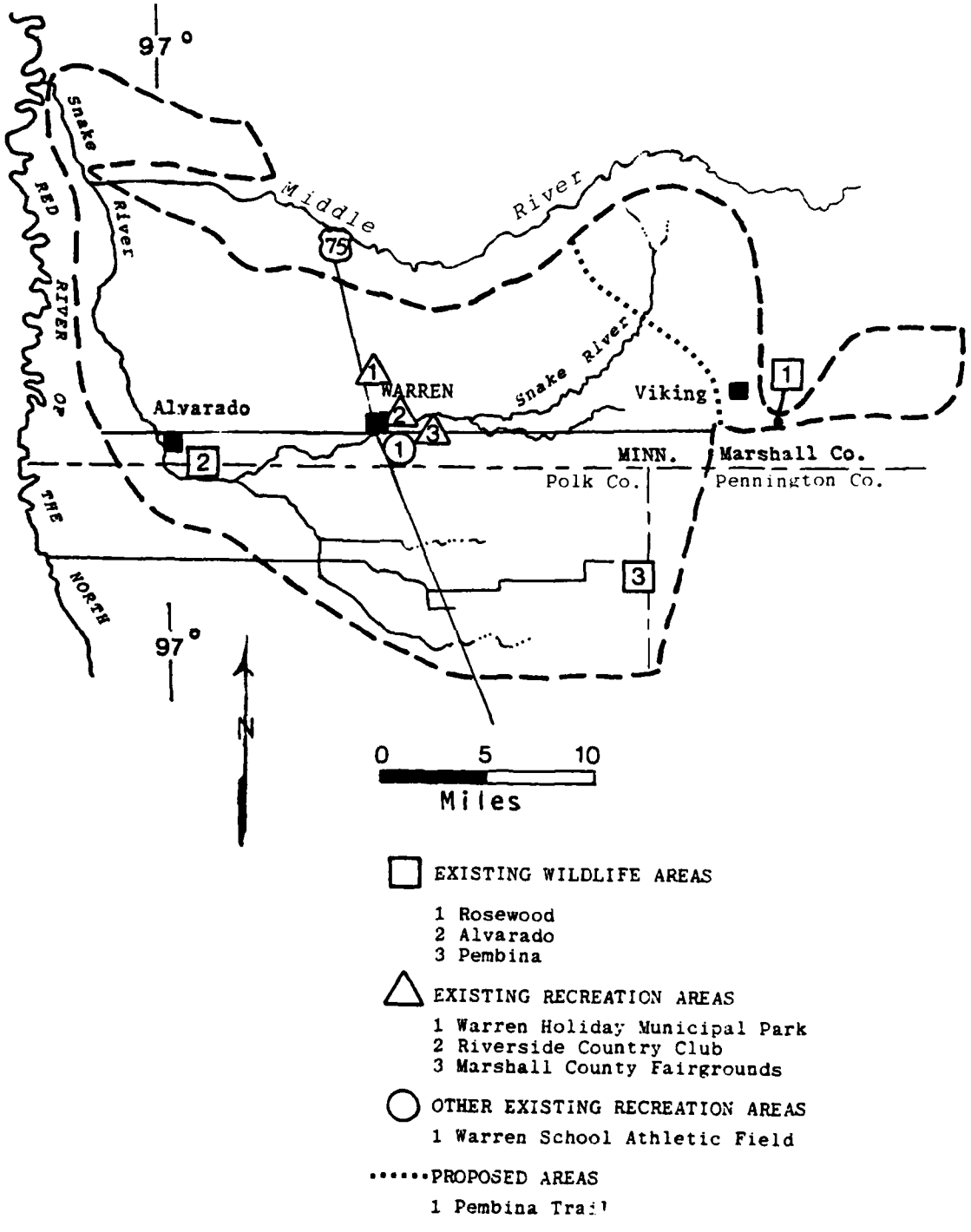
An archeological survey along the Snake River recorded 30 previously unknown sites between the confluence of the Snake and Red rivers and a point two miles east of Warren, Minnesota (Lane, 1975). Predictably enough, all of the sites located along the Snake River were relatively late-prehistoric, with a significant proportion of Woodland culture represented, including both Arvilla and Blackduck foci (Johnson, 1973; St. Paul District Corps of Engineers, July, 1979:31). The late nature of these sites is not surprising, since the subbasin was once innundated by Glacial Lake Agassiz. Not until after 3000 B.C. would the flat lucustrine plain of the subbasin have been available for continual occupation by prehistoric man (Lane, 1975; St. Paul Disrict Corps of Engineers, July, 1979).

Lane (1975:9) designated three classes of archeological remains, two of which do not appear to indicate a continuous occupation. Recent checks with the Minnesota Historical Society indicate that 22 archeological sites are recorded in the subbasin. Most of these are located along the Snake River west (and south) of Warren. The apparent association of known archeological resources with the Snake River and its tributaries could have significant impacts on the implementation of proposed flood control measures.

Although related tribes of the Dakota-Sioux once occupied the region, the Chippewa-Ojibwa Indians had gained control of the subbasin and the lower Red River Valley by 1820 (Hewes, 1948:49). The Chippewa land cessions made by treaties of 1855 and 1863 opened the rich agricultural lands of the Red River Valley to Euro-American settlement (Blegen, 1963: 172-173). A significant portion of the modern subbasin population is of Norwegian descent. Records of historic sites are scant, and no historical sites have yet been recorded in the subbasin. Systematic surveys should substantially improve the inventory of cultural resources.

Recreational Resources

Recreational resources are severely limited within the subbasin. There are only 13 recreational sites in the subbasin totalling about 4,125 acres. Seven areas larger than 15 acres account for 4,106 acres or 99 percent of the total recreational acreage. These sites are illustrated in Figure III.



Source: Gulf South Research Institute

Figure III. RECREATIONAL RESOURCE

An inventory of facilities for these sites is included in Appendix B of this report. Hunting and bird-watching opportunities are provided by three state wildlife management areas totalling approximately 3,920 acres; however, only a portion of the Rosewood Wildlife Management Area (2,900 acres) is included in the subbasin. Deer, some moose, rabbits, and squirrels are common species. Upland game birds include the partridge and ruffed grouse.

Snake River is an intermittent stream during summer months and is not considered a productive area for sports fisheries. The most common species taken include several forage fish such as redhorse, freshwater drum, and suckers.

The towns of Alvarado and Warren have small municipal parks and school athletic fields that provide residents with a variety of non-water based recreational activities, including camping, picnicking, swimming, and playgrounds. The only facility identified in Viking is a school athletic field.

The only proposed recreational site that has been identified is a portion of the Pembina Trail marking a former 126-mile ox cart trail through Kittson, Marshall, Pennington, Red Lake, Polk, and Norman counties.

Significant Environmental Elements

Social

Warren and Alvarado are the major population centers of the subbasin. Both towns and the surrounding agricultural areas have experienced severe flooding problems due to streambank overflow and sluggish overland flow. Residents of Alvarado constructed a dike following a major flood in 1966.

Urban damages from flooding include the disruption of water and sewer service, flooded basements, and some property damage to low-lying residential and commerical areas. Agricultural losses caused by flooding include damages to crops and equipment, loss of soils, and delays in planting. Extensive damage to roads and bridges causes inconvenience and adds to maintenance costs.

Cultural

The subbasin is rich in archeological resources. Most of the recorded archeological sites are associated with the Snake River, a fact that

could affect implementation of flood control alternatives. Data on historical sites are lacking in the study area. No historical sites have yet been recorded, but systematic surveys should substantially improve the inventory of cultural resources.

Soils

The subbasin contains undifferentiated alluvial soils in the river bottoms that appear in long narrow strips along the channels of streams. These soils range from clay to outwash sand and include loamy sands and silt loams. Only portions are cultivated, since these areas are poorly drained.

Soil types in the remainder of the subbasin are in three distinguishable categories. The western portion contains dark-colored, deep, fine-textured soils. Cultivation of the area is extensive although the soils are poorly drained.

The central region is composed of light-colored and moderately coarse to coarse textured soils. Poor water holding capacity is characteristic of these soils, which includes the gravelly beach ridges.

Proceeding eastward, dark colored, medium-to-moderately fine textured soils of glacial till are found. Soils in this portion of the subbasin generally have a silty clay loam to silty clay surface texture.

Water

Except for the Snake River, the subbasin does not have any large bodies of water. Less than 1.8 percent of the total land area is composed of water areas.

Woodlands

The woodlands and brushy areas of the subbasin are considered significant because of their value for wildlife habitats, including travel corridors, and because of their limited areal extent. Data from the MLMIS indicate that 8.3 percent of the subbasin's total area is forested, with about 90 percent of the remaining area in disturbed lands. Table 8 gives comparisons between percentages of woodland vegetation in 1969 and 1977 in the three counties included by the subbasin. Increases in woodlands, ranging from 1.6 to 5.6 percent, are shown for all three counties, probably as the

Table 8

COMPARISON OF COUNTY PERCENTAGES OF WOODLAND VEGETATION BETWEEN 1969 AND 1977

County	Percentage of County Containing Woodland Vegetation 1969	1977	Change in Percent Composition
Marshall	11.5	17.1	+5.6
Polk	5.1	6.7	+1.6
Pennington	6.4	9.9	+3.5

Source: Minnesota Land Management Information Service (in U.S. Fish and Wildlife Service, 1980).

result of the establishment of shelterbelts and windbreaks by local landowners around homesteads and tributary streams and revegetation of areas in the lower reaches of the floodplain that have not been cultivated in recent years (U.S. Fish and Wildlife Service, 1980).

One woodland of significance has been identified within the subbasin and has been described earlier. In summary, it is a 100-acre hardwood tract located along the Snake River upstream from Alvarado. Its uniqueness is related to the fact that it is one of the last substantial stands of timber along a stream in the intensely cultivated Red River Valley and also because it provides some of the best wildlife habitat within an eight-mile radius. It has been proposed for acquisition as a wildlife management area by the Minnesota DNR (U.S. Army Corps of Engineers, 1979a).

Wetlands

Wetlands are considered significant because of their many functional uses and values such as habitats for plants and animals, waterfowl production areas, groundwater recharge, floodwater retention, nutrient entrapment, etc. (Cernohous, 1979; U.S. Fish and Wildlife Service, 1980; E.O. 11990, dated 24 May 1977). Data supplied by the MLMIS indicate that there are

8,960 acres of marsh lands in the subbasin. Table 9 shows 1964 and 1974 wetland data for types 1 and 3-7 in Polk County; Marshall and Pennington counties were not included in these two inventories. The 1964 data represents a 25 percent sampling. All numbers except for Type 1 have been multiplied by four to give 100 percent values for numbers and acreages of wetlands. Type 1 wetlands were not measured in the 1964 survey; however, previous studies have indicated that they comprise about 10-15 percent of total wetland acres and 60 percent of total wetland numbers in the Prairie Pothole Region. This information was used to calculate Type 1 estimates. The 1964 data (expanded to 100 percent) is a conservative estimate. The 1974 survey represented a 100 percent inventory. In addition to the wetland types surveyed in the 1964 investigation, exclusive of Type 1 wetlands, Types 6 and 7 and stockponds are included.

Table 10 shows a comparison of the 1964 and 1974 wetland inventory data for Types 3-5. These data are comparable, since methods used in the 1974 survey allowed direct comparison of the same sampling locations at the 25 percent level sampling. These data show that wetland number and acreages in 1974 have been reduced by 297 and 1,458 acres, repectively, from 1964 totals (based on values-multiplied to 100 percent from a 25 percent sampling).

Waterfowl Production Areas

Waterfowl Production Areas (WPAs) are wetland areas that the U.S. Fish and Wildlife Service has either acquired through fee title or obtained an easement interest on to preserve valuable breeding, nesting, and feeding habitat for migratory waterfowl. There are no existing WPA's located within the subbasin.

Wildlife Management Areas

A total of three wildlife management areas or refuges are found within the subbasin. A list of these areas and their acreages and location were presented in the existing conditions section for recreation. These areas are considered significant because of the opportunities provided for outdoor recreation and protection and management given to biological resources within their confines.

Table 9

1964 AND 1974 WETLAND INVENTORY DATA FOR
POLK COUNTY, SNAKE RIVER SUBBASIN

	1964		1974		Total	
Type[a]	Number[b]	Acres[c]	Number	Acres	Number	Acres
1	1,721	2,718	--	--	1,721	2,718
3	2,097	5,340	1,432	8,413	3,529	13,753
4	537	5,251	438	4,138	975	9,389
5	234	7,526	351	15,745	585	23,271
6	--	--	416	4,277	416	4,277
7	--	--	4	40	4	40
Stock Ponds	--	--	146	--	146	--
TOTAL	4,589	20,835	2,787	32,613	7,376	53,448

[a]Type 1 = Seasonally flooded basins and flats.
Type 3 = Shallow fresh marshes.
Type 4 = Deep fresh marshes.
Type 5 = Open fresh water.
Type 6 = Shrub swamps.
Type 7 = Wooded swamps.

[b]Calculated at 60 percent of total wetland numbers.

[c]Calculated at 15 percent of total wetland numbers.

Source: U.S. Fish and Wildlife Service, 1980.

Table 10

COMPARISON OF 1964 AND 1974 WETLAND INVENTORY DATA SHOWING NUMBER, ACREAGE, AND PERCENT CHANGES FOR POLK COUNTY, SNAKE RIVER SUBBASIN*

Type	Number	Percent	Acres	Percent
3	-259	-12.4	+113	+2.1
4	-18	-3.4	-1,392	-26.5
5	-20	-8.5	-179	-2.4
Total	-297	-10.4	-1,458	-8.0

*Represents values multiplies to 100 percent from a 25 percent sample.

Source: U.S. Fish and Wildlife Service (1980).

Threatened or Endangered Species

The only mammal species that occurs in the subbasin and that is considered threatened or endangered is the eastern timber wolf. Portions of Marshall and Polk counties are within the timber wolf's peripheral range. Its primary range was originally throughout the eastern United States and southeastern Canada, but the timber wolf has since been extirpated from most of this range because of pressures from civilization. An endangered or threatened bird species, the bald eagle, occurs in the subbasin. The bald eagle has its peripheral nesting range in the two counties included in the subbasin. Also, the arctic peregrine falcon does not nest in the area, but its wintering range includes the entire subbasin. Both of these bird populations have been declining because of pesticide pollution (mainly DDT and its derivatives) and loss of habitat.

Other Important Species

Five mammal species of special interest are found in the subbasin: (1) least weasel; (2) long-tailed weasel; (3) spotted skunk; (4) plains pocket mouse; and (5) American elk. The least weasel is considered rare throughout its range in Minnesota, and the plains pocket mouse is known only from the northwest region of Minnesota (Department of Natural Resources Region 1N). The other species are peripheral and require additional studies to determine their exact abundance and distribution (Henderson, 1979).

The great blue heron was reported in the region (DNR Region 1N) during the 1978 breeding bird survey. This bird is not considered endangered or threatened. It is a species of special interest because its preferred nesting habitat (coniferous swamps) is rapidly vanishing. The marsh hawk and Franklin's gull are listed as having a changing or uncertain status, since they are uncommon or only local in abundance. Both were reported during the 1978 survey to be in the region. One threatened species, the eastern greater sandhill crane, was also reported during the survey. The primary reason for the sandhill crane's decline is the destruction and drainage of marshes and wetlands for agricultural purposes (Moyle, 1974). No colonial bird nesting sites have been identified in the subbasin (Minnesota Department of Natural Resources, 1978).

Reptiles that are considered to be of special interest and occur within the subbasin include the smooth green snake, Canadian toad, and great plains toad. Both subspecies (western and eastern) of the smooth green snake are found in Marshall and Polk counties. This snake is considered to be of special interest because, although it has an extensive range within the state, it is restricted to a limited habitat of moist, grassy areas that is rare in the subbasin (Henderson, 1979; Conant, 1975). The two toads are both western species that are within the extreme eastern edge of their ranges. The Canadian toad has been reported from both counties within the subbasin. The great plains toad has been recorded within the subbasin from only Polk County (Henderson, 1979).

The Dakota skipper and assiniboia skipper are butterflies that have been classified as rare by the Minnesota Natural Heritage Program (1980). Both of these have been reported from Polk County. Both of the skippers prefer the virgin prairies. The skippers have been disappearing along with the vanishing prairies.

The Minnesota Natural Heritage Program (1980) lists several plant species from Marshall and Polk counties as rare species. Carex capillaris var. major, Carex hallii, Carex obtusata, Scottish asphodel, starwort, and Platanthera leucophaea are rare plants that grow in the moist meadows of the subbasin. The dry plains and hills of the subbasin provide habitat

for rare species such as Gentiana affinins, Gentiana amarella, Potentilla effusa, reed grass, ragwort, cat's paws, and Chamaerhodos nuttallii (Rydberg, 1932, Lakela, 1965; MacMillan, 1898).

Natural Areas

Natural and scientific areas are lands that support a unique biotic community or provide other scientific or esthetic values. No natural areas have as yet been established in the subbasin (The Nature Conservancy, no date).

V. FUTURE CONDITIONS

V. FUTURE CONDITIONS

The subbasin's future economic, social, and environmental conditions and resources are discussed below in terms of "most probable" and "without project" conditions.

Most Probable Economic Conditions

The small communities of the subbasin, particularly Warren, will continue to serve the needs of the surrounding agriculture-based rural areas. Population, which increased by 6.6 percent between 1970 and 1977, will continue to grow (although at a slightly reduced rate) as will employment and per capita income, which is shown in **Table 11.**

Population and employment projections were developed by GSRI based on recent trends and state and regional estimates. OBERS E figures appear to underestimate growth trends for the non-SMSA portions of the Grand Forks area, since agricultural employment has stabilized and a slow reversal in population and employment decreases has been witnessed. OBERS E and E' projections were, however, designated as most probable for per capita income and agricultural activity estimates. Warren has been designated as a potential growth center by the Northwest Regional Development Commission.

A predominantly agricultural-based economy is forecasted to continue, with a negligible likelihood of economic diversification within this subbasin. Recurring flooding problems that affect some 130,000 acres and the towns of Warren and Alvarado are viewed by local leaders and planners as the biggest hindrances to economic growth and development.

Most Probable Agricultural Conditions

Approximately 314,000 acres within the subbasin are currently under cultivation, and wheat, barley and sunflowers are the principal crops produced. Estimated total value of these principal crops for 1980 (using October 1979 Current Normalized Prices for Minnesota) is $22.2 million. Projections of total production through 2030 for the principal crops is presented in **Table 12. The projected total production for 2030 represents** a value of $37.3 million (using October 1979, Current Normalized Prices for Minnesota).

Table 11

SNAKE RIVER SUBBASIN, POPULATION, EMPLOYMENT
AND PER CAPITA INCOME PROJECTIONS
1990-2030

Parameter	Year							
	1970	1977	1980	1990	2000	2010	2020	2030
Population	5,973	6,367	6,500	6,800	7,100	7,500	7,900	8,300
Employment	2,270	2,865	2,950	3,100	3,200	3,400	3,600	3,700
Per Capita Income (Dollar)	$4,085	$9,462	$11,400	$15,400	$21,100	$28,500	$38,500	$51,900

Sources: U.S. Water Resources Council, 1972 OBERS Projections, Series E; Northwest Regional Development Commission; and Gulf South Research Institute.

Table 12

SNAKE RIVER SUBBASIN, PRINCIPAL CROPS AND PROJECTED PRODUCTION, 1980-2030
(Production in Thousands)

Year	Wheat (Bushels)	Barley (Bushels)	Sunflowers (Pounds)
1980	4,689	2,801	38,218
1990	5,440	3,249	44,333
2000	6,190	3,697	50,448
2010	6,659	3,977	54,270
2020	7,128	4,257	58,092
2030	7,878	4,706	64,206

Sources: OBERS Series E'; and Gulf South Research Institute.

Evaluation of Flood Damages--Future Conditions

A summary of present and future average annual flood damages is presented in Table 13. Assuming a discount rate of 7 1/8 percent, average annual flood damages throughout the projection period are expected to be $474,200.

Flood damages to residences, businesses, industrial structures, churches, schools, automobiles, house trailers, public property and contents are included in the urban damages category. Damages to streets and utilities (including water, gas, electricity, sanitary sewers, storm sewers, and telephone systems) are also taken into consideration. This category also includes loss of wages, loss of profits, expenditures for temporary housing, cleanup costs, and extra expenses for additional fire and police protection and flood relief.

Agricultural flood damages consist of crop and pasture damage, which may include costs of replanting, refertilizing, additional spraying, reduced crop yields, loss of animal pasture days, and other related flood losses.

Other agricultural damages consist of land damage from scour and gully erosion and deposition of flood debris; livestock and poultry losses; damages to machinery and equipment, fences, and farm buildings and contents (excluding residences); and damages to irrigation and drainage facilities.

Table 13

SNAKE RIVER SUBBASIN, SUMMARY OF PRESENT AND FUTURE AVERAGE ANNUAL DAMAGES URBAN, AGRICULTURAL, AND TRANSPORTATION (October 1979 Prices, 7 1/8 Percent Interest)

Category	Flood Damages						Increase 1980-2030	Average Annual Equivalency Factor	Average Annual Equivalency of Increase	Equivalent Average Annual Damages
	1980	1990	2000	2010	2020	2030				
Urban										
Warren	32,100	35,300	38,500	41,700	44,900	48,200	16,100	0.2903	4,700	36,800
Alvarado	40,900	45,000	49,100	53,200	57,300	61,400	20,500	0.2903	6,000	46,900
Agricultural										
Crop	270,100	313,300	356,500	383,500	410,600	453,800	183,700	0.2903	53,300	323,400
Other Agricultural	54,000	58,300	62,600	65,300	68,000	72,400	18,400	0.2903	5,300	59,300
Transportation	7,800	7,800	7,800	7,800	7,800	7,800	--	--	--	7,800
TOTAL	404,900	459,700	514,500	551,500	588,600	643,600	238,700	0.2903	69,300	474,200

Source: Gulf South Research Institute.

Transportation damages include all damages to railroads, highways, roads, airports, bridges, culverts, and waterways not included in urban damages. In addition, all added operational costs for railroads and airlines and vehicle detours are included.

Future growth of urban flood damages was estimated to be an uncompounded (straight-line) rate of one percent per year for a 50-year period beginning in the base year, with no growth thereafter.

Agricultural crop flood damages were projected to increase at the same rate as crop income projections published in the 1972 OBERS Series E projection report. These crop income projections were prepared by the U.S. Economic Research Service (ERS) for the Red River of the North region. Other agricultural flood damages were projected to increase at one-half of this rate.

Transportation damages are not expected to change throughout the project life because of the long-term economic life associated with such structures as bridges, railways, roads, and culverts. In addition, it has been found that repairs to these types of structures rarely exceed the cost of a new structure, even with frequent flooding.

Most Probable Environmental Conditions

Upon implementation of adequate treatment procedures for industrial and municipal effluents, the water quality of the Snake River will improve. The water quality will be improved further after nonpoint pollution source controls are applied, although these controls are expected to take a considerably longer period of time to be implemented. The low dissolved oxygen levels will continue to exist during times of low flows and extreme winter conditions.

Barring any changes in current land use trends, woodland habitats are expected to gradually increase. Wetlands, on the other hand, will continue to decrease, both in number and areal extent. This reduction will result in decreased flora and fauna populations that require these wetland habitats. The low dissolved oxygen levels will continue to have a detrimental effect on the aquatic fauna of the river. The improved water quality, however, will help to improve the aquatic habitat, which will be beneficial to the aquatic and terrestrial wildlife as well.

Without Project Conditions

It is likely that the scenario set forth as the most probable future of the subbasin will prevail during the 50-year planning period in the absence of a plan to alter resource management programs.

VI. EXISTING FLOODPLAIN MANAGEMENT PROGRAMS

VI. EXISTING FLOODPLAIN MANAGEMENT PROGRAMS

Institutions

The development of effective water resources management practices in the subbasin is affected by the large number of Federal, state, and local agencies involved in project planning and implementation. There are 44 Federal agencies with various types of jurisdiction, and 14 directly involved in the water and related land resource planning process. At the state level, 27 agencies are involved. There are also regional commissions, county agencies, and municipal entities. Differences in perspective and problems of coordination hamper the effective and speedy resolution of problems.

The subbasin is aided in water resources development by its inclusion in the Middle River-Snake River Watershed District. The district deals with flooding, drainage, erosion, reclamation, water supply, waste disposal, and other problems related to water resources management. An overall plan for the watershed was developed in 1971.

The Marshall County and West Polk County soil and water conservation districts also have jurisdiction within the subbasin. The Corps of Engineers has not developed any projects in the area. Applications for PL 566 assistance for the Snake River, Angus-Oslo, and Melgaard-Swift Coulee Watersheds have been approved by the state Soil and Water Conservation Board. Authorization for planning the Snake River Watershed has been granted by the chief of the Soil Conservation Service; however, no work has been completed due to funding limitations. Levees constructed around the town of Alvarado by the city and snagging and clearing of the lower Snake River are completed flood control projects in the subbasin. Other projects include agricultural and farmstead ring levees. The Corps of Engineers, the Middle-Snake Watershed District, the Soil Conservation Service, the soil and water conservation districts, and the towns of Alvarado and Warren are the main entities that should be consulted in flood control planning for the subbasin.

It should be noted that the Northwest Regional Development Commission has developed an overall economic development plan that includes the subbasin area.

Structural Measures

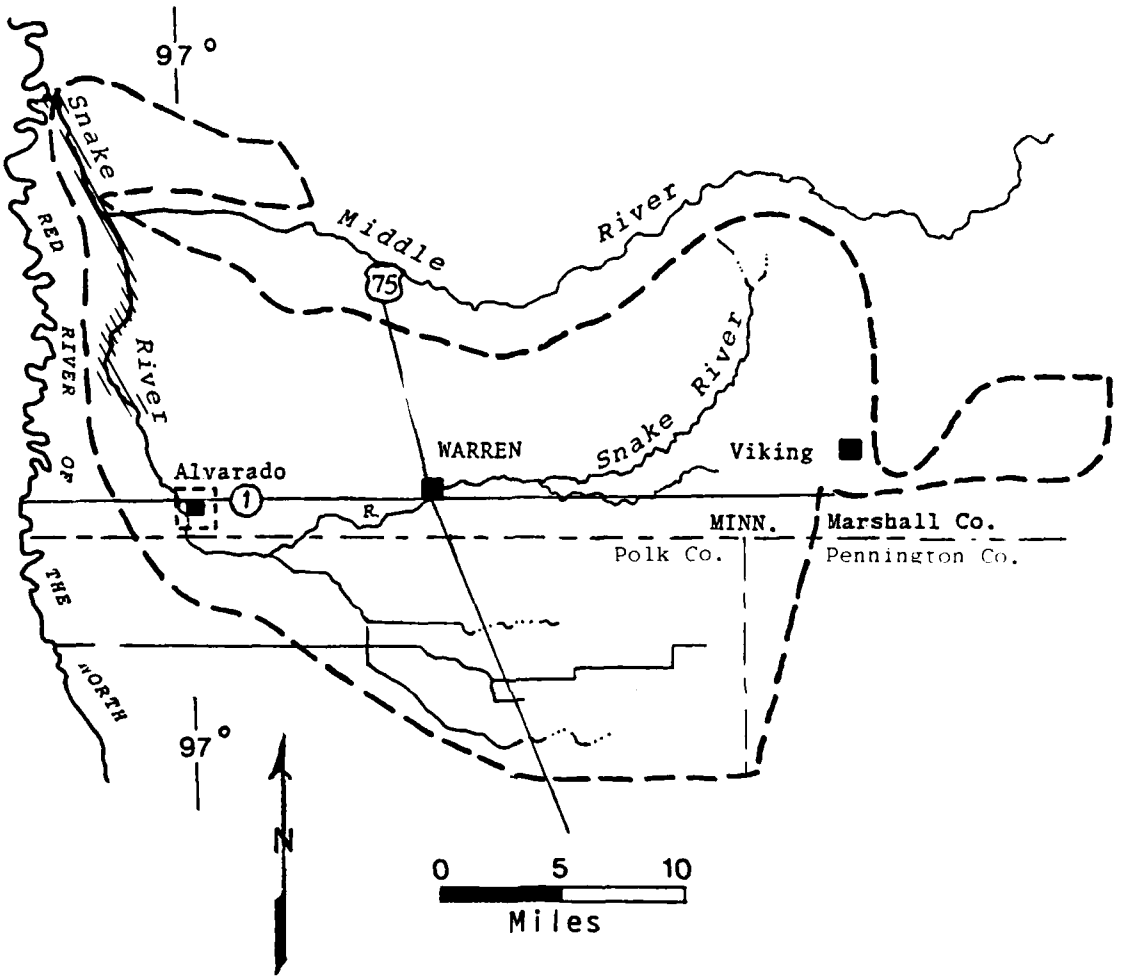
Numerous public and private drainage systems have been constructed throughout the subbasin. Generally, these drainage systems are functioning satisfactorily for frequent floods of short duration, but are totally inadequate for less frequent floods of prolonged duration. This situation is caused in part by the fact that the ditches are not being properly maintained; but the primary cause of flooding is that stream channels are not large enough.

No floodwater control and agricultural management (drainage) measures have been constructed in the subbasin by either the Corps of Engineers or the Soil Conservation Service (SCS). The Corps prepared a reconnaissance report, dated 17 October 1969, to determine the advisability of further detailed investigations of flood damage reduction measures for the City of Warren, Minnesota. Several alternative measures were investigated in this study. None were found to be economically feasible, and the District Engineer recommended that no further study be made at that time. The Middle River-Snake River Watershed District sponsored a snagging and cleaning project on the lower 20 miles of the Snake River in 1969 and 1979 following the 1969 flood. This work was funded by the State of Minnesota and the U.S. Office of Emergency Preparedness. The village of Alvarado, Minnesota, constructed a ring levee around the town in 1967 without the aid of Federal or state funds. This levee is about three to four feet high and was nearly overtopped during the 1969 spring flood. Extensive emergency efforts were needed to prevent its failure. Both of these measures are illustrated in Figure IV.

The Corps prepared another reconnaissance study relative to flood control measures on the lower 50 miles of the Snake River channel. This report, dated 18 August 1972, indicated that snagging and clearing the lower 50 miles of the channel to increase its capacity would be economically feasible and recommended further study. A detailed project report for further flood control on the lower 50 miles of the Snake River is now being prepared by the St. Paul District.

Nonstructural Measures

Nonstructural flood control measures are measures that reduce or eliminate flood damages through procedures that involve little if any



Source: Gulf South Research Institute.

Figure IV. EXISTING FLOOD CONTROL MEASURES

construction efforts. The major types are flood warning, floodplain zoning, flood insurance, flood proofing, and floodplain evacuation. These measures are primarily applicable to urban areas. Although urban flood damages in the subbasin are small, the counties in the subbasin as well as the towns of Alvarado and Warren, all participate in the Federal flood insurance program. Alvarado has a Floodplain Ordinance and a building code for floodplain areas.

Both of the towns participate in the Red River Valley flood warning system. The flood warning system for the Red River Valley is a cooperative network organized by the National Weather Service in Fargo, North Dakota. Fifty volunteers throughout the basin report to the National Weather Service on a weekly basis during winter and fall and on a daily basis during spring and summer. The reportage covers all precipitation of 0.1 inch or more, including amounts of snow and water equivalent. This information is transmitted to the River Forecast Center in Minneapolis, where it is run through a computer system to determine probable flood stages. The predictions are then transmitted to the National Weather Service in Fargo, which releases them to the public through the news media. Communities are then able to engage in emergency actions to protect themselves from flood damages. Contacts with local officials indicate that the flood warning system generally works quite well in the subbasin. The city of Warren also has a floodplain zoning ordinance and a building code for floodplain areas.

There are other types of measures that could be implemented in the subbasin to reduce flood damages but that are not directly applicable to urban areas. These measures would include such things as land treatment programs, use of present drainage ditches for floodwater storage, and use of natural areas for reversion to water retention use. Land treatment is used by some farmers in the subbasin, but the SCS has not been called upon to undertake a large-scale program. Present drainage ditches are not used for floodwater storage, and no plans have been developed for future use. Information on natural storage areas and potentialities for increased storage is limited. Indications are, however, that wetlands play a substantial role in controlling runoff. Values on storage have averaged about 12 inches per acre of wetlands (Cernohous, 1979).

Adequacy of Existing Measures

Public and private drainage systems constructed in the subbasin are functioning satisfactorily for frequent floods. However, they cannot handle large flood flows, and the basin sustains substantial damage during large floods. The ring levee around Alvarado does not adequately protect the town during less frequent floods. Indications are that floods of 20 percent (5-year) or less frequency cause extensive damage throughout the subbasin. Although existing drainage systems function satisfactorily for frequent floods, they are not extensive enough, and recurring flooding is still a problem throughout the subbasin even for frequent floods. Additional flood control measures are needed to reduce annual flood damages. The cleared channel from the mouth functions satisfactorily; however, channel conditions above this point are very poor and aggravate flooding conditions.

VII. CRITERIA AND PLANNING OBJECTIVES

VII. CRITERIA AND PLANNING OBJECTIVES

Floodplain Management Criteria

Technical, economic, and environmental criteria must be considered when formulating and evaluating alternative floodplain management measures for the subbasin.

The technical criteria used in formulating and evaluating alternatives for this report consisted of the application of appropriate engineering standards, regulations, and guidelines.

Economic criteria entailed the identification and comparison of benefits and costs of each measure. Tangible economic benefits or appropriate gains in environmental quality must exceed overall costs; however, in certain instances, considerations of appropriate gains in the other accounts (environmental quality, social well-being and regional development) could alter this requirement. All alternatives considered are scaled to a design which optimizes benefits. Annual costs and benefits are based on an interest rate of 7 1/8 percent and price levels and conditions existing in October 1979. A 50-year amortization schedule is used for the features considered.

Environmental considerations call for the formulation of measures that minimize objectionable or adverse environmental effects and maximize environmental benefits. Also, limited consideration was given to modifications based on coordination with state and Federal agencies, local interests, and citizen groups.

Planning Objectives

The primary planning objective of this study was to contribute to flood reduction needs in the subbasin and thereby provide protection from or reduction of flood losses. In conjunction with this economic objective, the study attempted to develop contributions to the environmental quality of the subbasin.

The development of planning objectives involved a broad-range analysis of the needs, opportunities, concerns, and constraints of the subbasin from the information that was available. On the basis of this analysis

of the problems, needs, and desires that could be identified, the following planning objectives were established:

1. Contribute to protection from and prevention, reduction, or compensation of flood losses for the flood prone areas of the subbasin during the period of analysis.
2. Contribute, to the maximum extent possible, to the preservation of the quality of the existing riverine environment and enhance the environmental potential of the subbasin as a whole.
3. Contribute to the enhancement of recreational opportunities throughout the subbasin.
4. Contribute to the improvement of water quality in the Snake River.
5. Contribute to the improvement of water supply in the western part of the shoreline area and throughout most of the lake plain.
6. Contribute to the reduction of wind and water erosion throughout the subbasin.
7. Contribute to the developing trend toward increased irrigation throughout the subbasin.
8. Contribute to the reduction of wastewater management problems, particularly insofar as they relate to water quality.

VIII. FORMULATION OF ALTERNATIVE MEASURES

VIII. FORMULATION OF ALTERNATIVE MEASURES

This section contains a discussion of management measures that have been identified to meet the resource management objectives. In the formulation of measures, prime consideration was given to the resolution of flooding problems. Measures to satisfy the other planning objectives were considered exclusively as components of the flood control measures.

Structural Measures

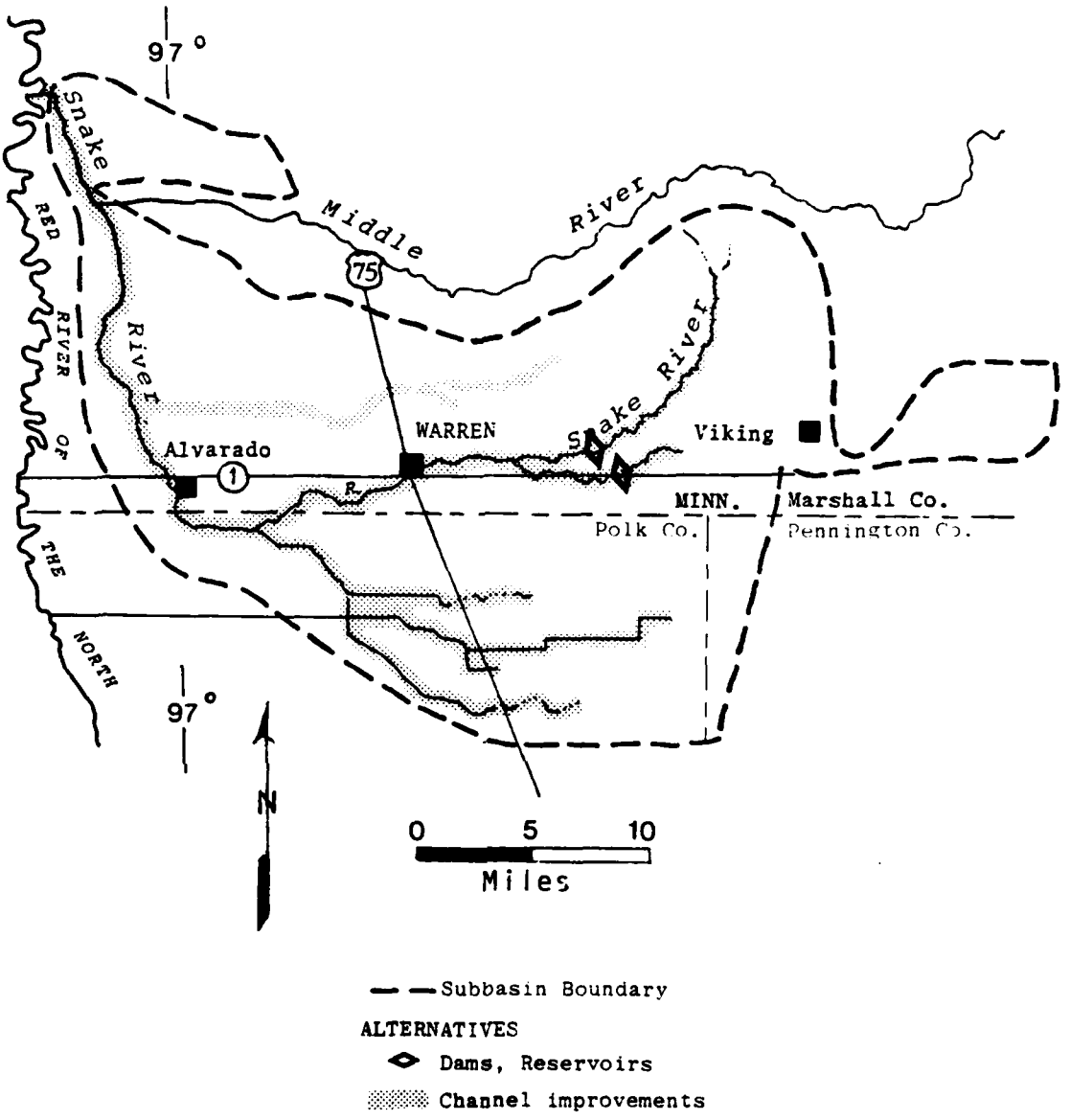
As a result of the favorable reconnaissance report of 10 August 1972, the St. Paul District proceeded with a detailed study of alternative flood damage reduction measures for the Snake River below Warren, Minnesota. This study investigated five different structural plans including the following:

1. Levees and floodway
2. Channel modification (10 percent)
3. Diversion channel
4. Three upstream reservoirs
5. Snagging and clearing

None of the first four plans was economically feasible, since all had benefit/cost ratios of 0.28 or less. The snagging and clearing plan is cost-effective and is the recommended structural plan for flood control on the Snake River.

In addition to the snagging and clearing plan, there are several other flood damage reduction measures that appear to have some merit for implementation by either public agencies or private interests. The following measures, shown on Figure V, were developed by this study in response to the flood planning objective:

1. Snagging and clearing the lower 50 miles of the Snake River from Warren, Minnesota, to its confluence with the Red River of the North. Since the channel has been cleared from the mouth to mile 20, work in this reach would consist of debris removal only. From river mile 20 to river mile 50, all accumulations of debris and snags within 20 feet of the primary channel would be removed. The removal of standing timber and brush would be limited to the lower two-thirds of the channel bank and would not significantly



Source: Gulf South Research Institute.

Figure V. ALTERNATIVE FLOOD CONTROL MEASURES

affect the canopy provided by the existing wooded corridor. The improved channel would be able to contain a flood with about a 25 percent frequency (four-year). The implementing agency for this alternative would be the Corps of Engineers.

2. Flood damage reduction measures and land treatment measures in the Melgard-Swift Coulee, Snake River, and Angus-Oslo watersheds. This alternative consists of flood storage reservoirs, stabilization structures, channel improvement, repairing existing channels and ditches, new ditch and drain construction, and various land treatment measures. In addition to flood control measures, this alternative includes measures for the improvement of recreation and fish and wildlife resources. These improvements would provide about 10 percent (10-year) flood protection for most of the subbasin. Applications for these watersheds have been approved and are in the priority pool for planning. The implementing agency for these measures would be the SCS.

3. Construction of levees around individual farmsteads in the one percent (100-year) floodplain. These levees would protect individual farmsteads against the one percent flood and could be constructed by the SCS, the Corps of Engineers, or private interests.

Engineering Methodology

The various alternatives and resulting benefits were extracted from prior studies relative to flood damage reduction in the Snake River subbasin. Capital costs for the snagging and clearing alternative were obtained by updating the October, 1978 estimated cost to the October, 1979 level using "Engineering News-Record" cost indexes. Data available in the prior reports and studies did not form a sufficient base for estimating capital costs for the three watershed alternatives. In order to estimate the capital costs of these alternatives, a composite cost per acre for watershed improvement was developed by updating the costs of all completed Minnesota watershed projects to October, 1979 levels using "Engineering News-Record" cost indexes and the total acreage included in the projects.

Nonstructural Measures

Nonstructural measures can often effectively reduce flood damages and were considered for flood-prone areas along the Snake River below Warren. Nonstructural measures considered include flood warning, emergency protection, flood insurance, flood proofing, floodplain regulation and permanent floodplain evacuation. The following paragraphs describe the conclusions reached by that study.

The subbasin is provided with flood forecasts and warnings by the National Weather Service, area officials, and local news media. However, flood warnings with subsequent emergency actions could reduce approximately two percent of flood damages in the subbasin. Therefore, this plan would have no significant beneficial effects on the economic development, environmental quality, and social well-being of the study area. Actual costs and benefits of such a plan cannot be determined because accuracy of the flood warnings and adequacy of the emergency actions taken are uncertain. This plan would not be effective as a long-term flood damage reduction measure.

Alvarado, Warren and Marshall County all participate in the Federally-subsidized flood insurance program. Flood insurance does not solve flood problems or reduce flood damages, but spreads the monetary loss over a wider segment of the population. Thus, flood insurance cannot be considered an acceptable long-term solution to flood problems under study or a very suitable short-term solution because of the lack of acceptance due to high costs.

Flood proofing involves structural changes and adjustments to flood-prone properties for flood damage reduction. Implementation of this alternative would not have a beneficial effect on the major damage categories in the subbasin, and it is estimated that flood proofing would alleviate only nine percent of the total average annual flood damages.

Floodplain regulation is a measure for modifying future land use and development so as to lessen the future effects of floods, but it cannot eliminate or control flooding. Thus, floodplain regulations would not provide a significant degree of flood damage reduction and could eliminate no more than six percent of total average annual damages.

Permanent floodplain evacuation and conversion of land use involves removal and relocation of all improvements including farmsteads, other structures, equipment, etc. from the floodplain; evacuation and resettlement of the population; and permanent conversion of such lands to less flood damage susceptible land use. This measure was totally unacceptable to the local interests and was found to be economically unfeasible, with an estimated benefit/cost ratio of 0.02.

Besides the nonstructural measures mentioned in the Corps report, there are opportunities for implementation of other nonstructural measures in the subbasin. There is an opportunity for the use of land treatment measures throughout the subbasin that would help to contain water on land as well as reducing erosion damages. These measures were mentioned for some of the areas of the subbasin in connection with structural alternatives described above, but could be implemented throughout the subbasin. Potentials for water retention in existing ditches should be considered. Natural retention areas should also be considered for preservation. However, these would need to be identified, and their retention capacities would need to be determined. There may also be opportunities for wetland restoration. In addition, floodplain regulation should be implemented at Alvarado, even if this alternative would not significantly reduce flood damages in the subbasin.

IX. ASSESSMENT OF ALTERNATIVES

IX. ASSESSMENT OF ALTERNATIVES

Economic Assessment

Overbank flow together with sluggish overland flow has frequently inundated farmland as well as the urban areas of Warren and Alvarado. The subbasin is very flat, and the featureless terrain is poorly drained.

An economical evaluation of the various flood control measures that have been designed for the subbasin are presented in Table 14. Alternative 1 involves snagging and clearing of the lower 50 miles of the Snake River from Warren, Minnesota, to its confluence with the Red River of the North. The improved channel would be able to contain a 25 percent frequency (four-year) flood. Economic analysis of this alternative yielded a benefit/cost ratio of 1.95. Average annual costs and benefits were updated from 1978 to October 1979 levels using the Gross National Product (GNP) indexes.

Alternatives 2, 3, and 4 were watershed improvement plans for the Melgard-Swift Coulee, Snake River, and Angus-Oslo Watersheds. The alternatives consist of flood storage reservoirs, stabilization structures, channel improvements, repairing existing channels and ditches, new ditch and drain construction, and various land treatment measures. In addition to flood control, the alternatives include measures for the improvement of recreation and fish and wildlife resources. These alternatives would provide about 10 percent (10-year) frequency flood protection for most of the subbasin. Average annual benefits for these alternatives were updated from June 1971 to October 1979 price levels. Economic evaluation of alternatives 2, 3, and 4 yielded benefit/cost ratios of 1.74, 1.70 and 1.79, respectively.

Alternative 5 involves the construction of farmstead levees around individual farmsteads located in the one percent (100-year) frequency floodplain. The levees would provide protection against the one percent (100-year) frequency flood. Economic evaluation of this alternative yielded a benefit/cost ratio of 2.10. The evaluation considered implementation of this alternative by private interests.

Table 14

ECONOMIC EVALUATION OF ALTERNATIVES, SNAKE RIVER SUBBASIN

Alternatives	Acres Protected	Average Annual Acres	Capital Costs	Average Annual Costs	Average Annual Rural Benefits	Average Annual Urban Benefits	Total Average Annual Benefits	B/C Ratio
1. Channel Improvements Snagging and Clearing (25 percent flood)	402,600	--	$ 636,000	$ 60,400[1]	$ 90,000[1]	$27,800	$117,800	1.95
2. Channel Improvements Melgard-Swift Coulee Watershed (10 percent flood)	95,400	--	2,414,000	177,700	309,700[2]	--	309,700	1.74
3. Upstream Reservoirs (2) Snake River Watershed (10 percent flood)	135,000	--	3,446,000	253,700	432,500[2]	--	432,500	1.70
4. Channel Improvements Angus-Oslo Watershed (10 percent flood)	172,200	--	4,357,000	320,700	572,900[2]	--	572,900	1.79
5. Farmstead Levees (per levee)	--	--	5,600	400	840	--	840	2.10

[1] October 1978 figures updated to October 1979.

[2] June 1971 figures updated to October 1979.

Source: Gulf South Research Institute.

Impact Assessment

Five structural measures were investigated for their anticipated effects on key resource elements in the event of implementation. The following discussion elaborates on the rationale pursued in the assignment of ratings presented in Table 15.

Channel Improvements

Channel improvement measures were considered for the Snake and several of its tributaries, particularly smaller creeks, coulees, and ditches. By and large these improvements would yield moderate to maximum beneficial social and economic effects and a similar level of adverse biological and water quality effects. No known effects would take place with respect to water supply, cultural and recreational elements, and land use.

Social and economic benefits would accrue through various levels of flood protection afforded by the specific measures. Protection would range from over 95,000 acres, if the 25 miles of improvements to the Melgard-Swift Coulee Watershed were implemented, to nearly 400,000 acres if snagging and clearing of the lower 50 miles of the Snake River were to take place. All channel improvements would contain at least the 10 percent flood.

Only the snagging and clearing improvements would have minimal adverse effects on fish and wildlife resources and water quality, since the channel is not highly productive and might ultimately benefit from improved flows. All other channel improvements would have maximum/moderate adverse effects on these elements, mostly due to changes in the character of the existing water bodies and their habitat features.

Upstream Reservoirs

Two small upstream impoundments with a total storage capacity of 9,800 acre-feet would also have moderately beneficial social and economic effects. The benefits would occur mostly from protecting some 135,000 acres from flooding. Recreation and water quality would be beneficially, although minimally, affected whereas moderately adverse results would be experienced by biological elements, largely due to the disruptions

Table 15

ASSESSMENT OF MEASURES, BY RESOURCE ELEMENT, SNAKE RIVER SUBBASIN

Measures	Social	Economics	Land Use	Biology	Water Quality	Water Supply	Cultural	Recreation
Channel Improvements - Snagging and Clearing	MoB	MoB	NKE	MiA	MiA	NKE	NKE	NKE
Channel Improvements - Melgard-Swift Coulee	MoB	MoB	NKE	MoA	MoA	NKE	NKE	NKE
Upstream Reservoirs - Snake River	MoB	MoB	NKE	MoA	MiB	NKE	NKE	MiB
Channel Improvements - Angus-Oslo	MoB	MaB	NKE	MaA	MaA	NKE	NKE	NKE
Farmstead Levees	MiB	MiB	NKE	NKE	NKE	NKE	NKE	NKE

Note: NKE = No Known Effect
MiA = Minimally Adverse
MoA = Moderately Adverse
MaA = Maximally Adverse
MiB = Minimally Beneficial
MoB = Moderately Beneficial
MaB = Maximally Beneficial

Source: Gulf South Research Institute.

and changes in the existing habitat. No known effects would take place for land use, water supply and cultural elements.

Farmstead Levees

Localized minimally beneficial economic and social effects would result from the protection of farmsteads from frequent floods by development of ring levees. Other resource elements would not be notably affected, although aesthetic, sanitary, and maintenance factors would need to be considered. Negative environmental effects would, however, take place if the levees were to infringe on wetlands.

X. EVALUATION

X. EVALUATION

All five alternative structural measures considered for the Snake River Subbasin had benefit/cost ratios that exceed unity.

All structural measures would have favorable social well-being effects, with the greatest impact stemming from the measure that would afford urban protection to Warren and Alvarado. The channel improvements in the Angus-Oslo Watershed area appear to maximize net economic benefits for the subbasin, but only protect some 172,000 acres. Other proposed channel improvement measures have similar or higher benefit/cost ratios and afford more protection, but the increment in benefits is smaller than with the Angus-Oslo alternative.

The farmstead ring levees also exceed the above unity criteria but do not notably benefit the resolution of subbasin flooding problems.

Environmental enhancement benefits would accrue from the measures that include land treatment. The greatest impact would probably occur as a result of upstream reservoir construction in the Snake River Watershed area.

National Economic Development (NED) and Environmental Quality(EQ) plans will be tentatively formulated in association with the main reconnaissance report for the Red River of the North Basin.

XI. ADDITIONAL STUDY NEEDS

XI. ADDITIONAL STUDY NEEDS

This report was developed almost entirely on the basis of secondary information from readily available planning documents. Data available from state and Federal agencies was not fully canvassed, and only a limited number of calls were made to the area. In particular, state university libraries and department resources could not be fully utilized. Thus, the document aims only at a broad-brush perspective. In order to provide a more detailed and in-depth analysis of subbasin resources, problems, and potential solutions, the following additional study needs would have to be fulfilled:

1. A literature search should be conducted to obtain available biological data for the subbasin. Fieldwork should be planned to fill in any data gaps which exist with the end result of obtaining good baseline date for the subbasin. This is particularly necessary in those areas where flood control measures have been proposed.

2. Areas of high environmental quality (e.g., prairie remnants) should be identified and inventoried within the subbasin.

3. Knowledge of the location, areal extent, and types of wetlands occurring within the specific subbasin boundaries would be extremely useful in determining whether wetland restoration would assist in alleviating flooding problems, as has been indicated by Cernohous (1979).

4. Primary water and sediment quality data are needed to characterize baseline conditions in the streams of the subbasin, particularly in those areas where flood storage reservoirs and channelization have been proposed.

5. Information pertaining to wastewater management needs to be updated.

6. The information obtained in items 1-5 above would provide an important data base upon which an impact evaluation of proposed flood control measures can be performed, and would provide information relative to the cumulative effects of flood control projects on environmental resources in the subbasin. These projects include those that are in-place or proposed.

7. Nonstructural flood damage reduction measures should be thoroughly explored such as those listed below.

   . Establishment of buffer areas and curtailment of inappropriate residential, commercial, and other development in floodplains.

- Maintenance and enhancement of existing riparian vegetation along the Snake River and tributaries to conserve and restore wildlife habitats, help control wind and streambank erosion, retain soil on the land, and to reduce the amount of sediment, nutruients, and other pollutants entering waterways.
- Maintenance of grassed waterways to reduce erosion.
- Establishment of vegetation in areas of critical erosion.
- Determination of the feasibility of installing water control structures at existing culverts to retain water in drainage ditches for longer periods of time during critical runoff periods to minimize flooding in downstream areas.
- Determination of the feasibility of utilizing "on-farm storage" to control runoff through such means as natural storage areas and control structures on existing culverts.
- Prevention of overgrazing on grasslands and utilization of sound agricultural land use practices.
- Provision for strict enforcement of floodplain management programs within the subbasin.

8. The potentiality for land treatment measures (e.g. erosion control measures such as cover crops, green belts, reduction in fall tillage, etc.) needs to be thoroughly investigated.
9. The people of the subbasin need to be included in further water resource planning efforts. A public involvement program would provide more complete information on water resource problems and opportunities than is presently available.
10. Studies are needed to determine additional demand for recreational facilities, usage of existing facilities, and potential sites.
11. A review of secondary sources and systematic field reconnaissance is needed to identify archaeological and historical sites and to determine their eligibility for nomination to the National Register of Historic Places.
12. A detailed social profile of the subbasin is needed.
13. A detailed institutional analysis of the subbasin is needed.
14. Subbasin boundaries need to be better defined on the basis of hydrologic conditions, and total acreage in the subbasin needs to be precisely measured.

15. An adequate 100-year floodplain map needs to be developed. Also, the extent of floodplains for smaller frequency storms needs to be delineated.

16. Land use within the floodplain needs to be precisely identified.

17. The irrigation potentials of the subbasin soils need to be investigated.

18. The effect of drainage works on flood discharges and stages is unknown at present. It would take additional, more detailed studies to determine the extent and effect of reduced natural storage.

19. Potentialities for floodwater storage in present drainage ditches need to be investigated.

20. Crop distribution in the floodplain needs to be precisely identified through contact with county agents, and average annual rural damages need to be updated.

21. Urban damages need to be recomputed in a systematic fashion.

22. Whether forested acreages in the floodplain are increasing or declining needs to be precisely determined.

23. More study is needed to determine the precise nature of the water supply problems and potential solutions.

24. More gauging stations need to be developed to provide hydrologic data for establishing flood frequencies and rating curves.

25. Channel cross sections of the various streams need to be prepared for flood control planning purposes.

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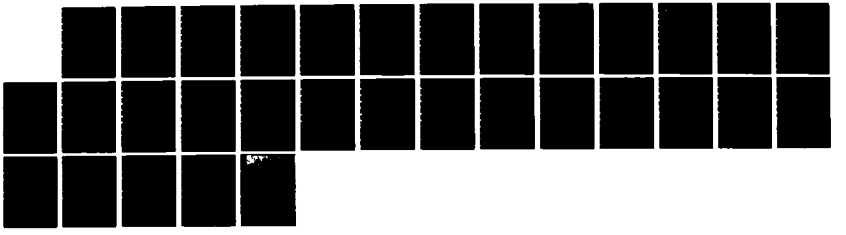

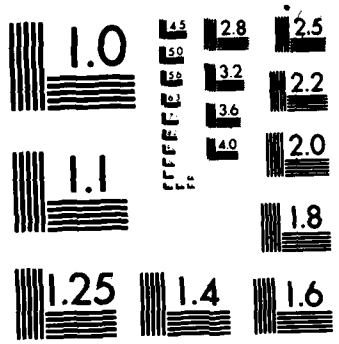

Appendix A

FLOODPLAIN DELINEATION

Appendix A
FLOODPLAIN DELINEATION

Prior to this study, no attempt was made to publish even a generalized delineation of the entire Snake River floodplain. In undertaking this task, the present study utilized all known sources to provide the best available data for generalized delineation at a scale of 1:250,000. Principal sources were: USGS Flood Prone Area Maps (scale 1:24,000), Federal Insurance Administration flood maps (various scales), published secondary sources, U.S. Geological Survey (USGS) 7 1/2 minute topographic maps, and other sources, including derived data where necessary.

The scarcity of available data for the subbasin (particularly Marshall County) resulted in a thorough search of available data. The Flood Prone Area Maps published by the USGS provided detailed and accurate information for the area mapped. Unfortunately, only the portion of the subbasin in the extreme eastern end was available.

Federal Insurance Administration Flood Hazard Boundary Maps and Flood Insurance Rate Maps provide important coverage of the Minnesota portion of the Red River Basin. The former are designed only to delineate the 100-year floodplain. The latter are much more detailed and usually more accurate. Marshall and Pennington counties are two of four counties for which a map of the unincorporated area has not yet been published.* The southern one-third of the subbasin lies in Polk County, for which a Flood Hazard Boundary Map has been completed. Flood Hazard Boundary Maps for the cities of Warren and Alvarado provided limited, although useful, information.

Secondary sources, such as the Souris-Red-Rainy River Basins Type II Study (delineating the Red River main stem floodplain) were also utilized. Published floodplain descriptions and acreages in the Middle River-Snake River Watershed District Overall Plan and other sources were consulted. U.S. Geological Survey 7 1/2 minute topographic maps of the southern half of the subbasin were not available for consideration at the time the floodplain delineation was being made.

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*These counties entered the emergency flood insurance program in 1974. Edwards and Kelcey, Inc., of Minneapolis has been awarded a contract to provide such studies, which should be completed by mid 1981.

Where published information was lacking, as in the northern half of the subbasin, the extent of the floodplain was inferred from gallery forests along old meander channels and marsh patterns indicated on the USGS 250,000- and 24,000-scale maps.

As noted earlier, data from the above sources was compiled and delineated on USGS 250,000-scale maps. The floodplain indicated was then planimetered, with figures in square inches converted to acres and rounded to the nearest 2,000 acres.

Appendix B

INVENTORY OF OUTDOOR RECREATIONAL FACILITIES,
SNAKE RIVER SUBBASIN

Appendix B

INVENTORY OF OUTDOOR RECREATIONAL FACILITIES (WILDLIFE MANAGEMENT AREAS)
SNAKE RIVER SUBBASIN

Number	Name	Location	Boundary Acres	WMA Managed Acres	Date[1]
1	Rosewood WMA	Marshall Co. 15544W31 New Solum Township	2,900.0	921.4	76
2	Alvarado WMA	Polk Co. 15449W08 Alvarado	100.0		76
3	Pembina WMA	Polk Co. 15346W13 Brandt Township	3,860.0		71
		Total Acres:	6,860.0	921.4	

[1]Date of latest information.

Source: Minnesota Department of Natural Resources, Division of Parks and Recreation.

Appendix

INVENTORY OF OUTDOOR RE
SNAKE RIV R

Number	Name	Own	Administration	Location	Boundary Acres	Number of Resort Units	Campground			Wildlife Management
							Primitive	Modern	Group	
(1)	Warren Holiday Municipal Park	Municipal		Marshall Co. 15548W36 Warren	32.0		15	12		
(2)	Riverside Country Club	Private		Marshall Co. 15547W31 Warren	84.0			24		
(3)	Marshall County Fairgrounds	County		Marshall Co. 15547W31 Warren	50.0					
(1)	Warren School Athletic Field	School		Marshall Co. 15448W01 Warren	20.0					

[1]Facilities included are limited to those with 15 or more acres.

[2]Boat rental.

[3]Boat storage.

[4]Parking spaces.

[5]Date of latest facility information.

Source: Minnesota Department of Natural Resources, Division of Parks and Recreation.

Appendix B

OF OUTDOOR RECREATIONAL FACILITIES[1]
SNAKE RIVER SUBBASIN

pground					Marina									Trails (Miles)										
Modern	Group	Wildlife Management Acres	Athletic Field Acres	Golf	Canoe	Rental[2]	Storage[3]	Playground	Park[4]	Ramp	Picnic Table	Beach	Pool	Nature	Horse	Snow	Hike	Bike	Ski	Trout	Shooting Range	East Area	Fairground	Date[5]
12			8					X			24		X											76
24			5	9				X			40		X											76
																							X	76
			20					X																75

2

Appendix C

COMMENTS

Appendix C

COMMENTS

The purpose of this subbasin report was to provide an overview of the water and related resource problems and needs and to assess potential solutions. Toward this end, draft copies of this report were circulated to Federal, State, and local agencies and comments were sought.

This review resulted in complete and factual documentation. Thus, the study should serve as a building block for the timely completion of future water resource efforts within the subbasin. Further cooperative efforts are, however, needed to evaluate these tentative results and to develop potential solutions.

A distribution list and copies of the comments made with respect to the draft report are included as part of this appendix. Comments that resulted in specific modifications to the draft text are marked by an asterisk.

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT CORPS OF ENGINEERS
1135 U S POST OFFICE & CUSTOM HOUSE
ST PAUL, MINNESOTA 55101

REPLY TO
ATTENTION OF:

NCSED-PB

18 August 1980

Mr. Mike Liffmann
Project Manager
Gulf South Research Institute
8000 GSRI Avenue
Baton Rouge, Louisiana 70808

Dear Mr. Liffmann:

The draft Snake River subbasin report was distributed for review and comment. Most of the reviewers have sent their comments to us.

a. Inclosure 1 includes letters from various Federal and State agencies.

b. Inclosure 2 is the general office comments that need to be considered when preparing the final Snake River subbasin report and the remaining subbasin reports or the overall document.

c. Inclosure 3 identified specific office concerns that are applicable to the Snake River subbasin report.

If you have any questions on our comments or proposed modifications, please contact us.

Sincerely,

Louis E Kowalski

LOUIS E. KOWALSKI
Chief, Planning Branch
Engineering Division

3 Incl
As stated

United States
Department of
Agriculture

316 North Robert St., Room 200
St. Paul, Minnesota
55101

In reply refer to: 150-13 Red River of the North Date June 1

To: William W. [illegible], Colonel
Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, [illegible]

We have reviewed the Snake River and Sand Hill River Subbasins draft reports for the Red River of the North Reconnaissance Study being conducted by GSRI under contract for the St. Paul District U.S. Army Corps of Engineers. The following comments are provided for your consideration:

Snake River Subbasin

*1. On page 3, paragraph 2, the elevation at the mouth of the Snake River is described as being about 75 feet. This should be reviewed for accuracy. Also the statement, "The difference in elevation from east to west is 1,075 feet" should also be reviewed for accuracy.

*2. On page 3, paragraph 3, the drainage area of the Snake River is described as being 402,560 acres. The drainage area at the mouth of the Snake River should include the Middle River drainage area, however, it appears that this acreage only includes the Snake River subbasin drainage area. This should be clarified for the reader.

*3. A portion of the subbasin is located in Pennington County. This item should be clarified on the map on page 4 as well as other maps in the report.

*4. It is suggested that the wording in the 2nd sentence, last paragraph on page 7 be changed as follows: "Prior to this study no attempt had been made to publish even a generalized flood plain delineation of the entire subbasin."

*5. In the first full paragraph on page 10, the figure of $404,900 should be changed to read $404,000 to agree with the figures shown on page 11.

*6. It is suggested that the third paragraph on page 49 starting [illegible] sentence be revised to read [illegible] the Snake River, [illegible], and [illegible] Watersheds have been approved by the State Soil and

Water Conservation Board. Authorization for planning the Snake River Watershed has been granted by the Chief of the Soil Conservation Service, however, no work has been completed due to funding limitations. Levees constructed around the town of Alvarado...

*7. On page 51, the map shows that SCS has an authorized channel improvement project in the lower part of Snake River. This is not the case, therefore, SCS should not be credited for any channel work in this area.

Sand Hill River Subbasin

1. There are numerous typographical errors throughout the report. One such case is on page 8 where the term Kittleson Creek is misspelled. These typographical errors should be corrected.

2. On page 14, there are numerous abbreviations that are not described. These abbreviations should be referenced for the benefit of the reader.

3. Page 22, Bemidji is misspelled. This should be corrected so as not to offend any of the readers in that area.

4. On page 24, third line, the term futile should probably be changed to fertile.

5. On page 32, the second paragraph, there is a reference to the Ojibway Indian Tribe. In other places in the report conflicting spellings have occurred - Ojibwa and Ojibway. These should be reviewed and changed for consistency.

6. On page 58, the discussion of frequency of flooding is discussed. The term "100-year flood" is used or the "1 percent flood" is used. The recommended terminology for SCS usage is either the "100-year frequency flood" or the "1 percent chance flood." These discrepancies appear throughout the report and should be corrected.

Jon V. DeGroot
Assistant State Conservationist

cc: [illegible] Wilkinson, [illegible]

USDA:SCS:IRWilkinson:WPC:ldh:6/20/80

United States Department of the Interior

IN REPLY REFER TO:

FISH AND WILDLIFE SERVICE

St. Paul Field Office, Ecological Services
538 Federal Building and U.S. Court House
316 North Robert Street
St. Paul, Minnesota 55101

July 10, 1980

Colonel William W. Badger
District Engineer, St. Paul District
U.S. Army Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Badger:

This provides U.S. Fish and Wildlife Service comments on the Draft Reconnaissance Report recently compiled by Gulf South Research Institute for the Snake River Subbasin in Marshall, Polk, and Pennington Counties, Minnesota.

As expressed in our comments on previous Subbasin Reports, our concerns are associated with the woodland, grassland, wetland, riverine, and riparian floodplain habitats that remain within the Snake River Subbasin. Most of the grassland, woodland, and wetland habitat in the western part of the Subbasin has been converted to agricultural uses. The remaining woodland and grassland vegetation in the western part of the Subbasin is primarily restricted to the floodplain of the Snake River. We agree with the statements on pages 12 and 28 of the Report that the riparian woodland habitat along the Snake River (particularly in the western part of the Subbasin) is significant as a migration and travel corridor for wildlife and that these and other remaining woodland, grassland, and wetland habitat types within the Subbasin need to be conserved and enhanced.

Another area of concern is the 100 acre tract of bottomland hardwoods located along the Snake River upstream from Alvarado which has been proposed for acquisition by the Minnesota Department of Natural Resources as a wildlife management area. We agree that this area is unique (as indicated on pages 13, 27, and 37 of the Report) and should also be preserved within the Subbasin.

The Report addressed five structural alternative measures that have been considered to date to reduce the flooding problems within the

Subbasin. Our comments relative to these various structural measures (channel improvements, reservoirs, and farmstead levees) are similar to those expressed on previous Subbasin Reports. We believe a combination of structural and nonstructural measures (as provided on page 4 of our May 8, 1980 letter on the Draft Reconnaissance Report for the Tamarac River Subbasin) should be implemented. We also believe that additional studies (particularly numbers 2, 3, 7, 8, 18, and 19 identified on pages 67-69 of the Report) need to be undertaken to provide a more detailed and in-depth analysis of existing Subbasin problems and the potential solutions to many of these problems.

In addition, we suggest that the following changes be made in the Final Report:

*1. Page 40, 2nd paragraph (under the heading Waterfowl Production Areas) - change this paragraph to read as follows:

Waterfowl Production Areas (WPA's) are wetland areas that the U.S. Fish and Wildlife Service has either acquired through fee title or obtained an easement interest on to preserve valuable breeding, nesting, and feeding habitat for migratory waterfowl. There are no existing WPA's located within the Snake River Subbasin.

*2. Page 52, 2nd paragraph, last sentence - we suggest this sentence be changed and the following statements be included in this paragraph:

Information on natural storage areas and potentialities for increased storage is limited. Indications are, however, that wetlands play a substantial role in controlling runoff, especially in combination with good land treatment practices. Values on storage have averaged about twelve inches per surface-acre of wetlands, and have ranged to four times that amount (Cernohous, 1979). The amount of wetland habitat within the watershed area (or Subbasin) is important: statistical studies indicate that in certain situations if a watershed has 15 percent of its area in wetlands or lakes, peak floods will be 60 to 65 percent lower than they would be in the absence of the wetland/lake area; if wetlands or lakes occupy 30 percent of the watershed, there will be a further reduction in flood peaks up to about 75 to 80 percent (Scientists' Report, National Symposium on Wetlands, 1978).

*3. Page 73, BIBLIOGRAPHY - include the following reference on this page:

National Wetlands Technical Council, 1978. Scientists' Report, National Symposium On Wetlands. 129 pp.

These comments have been prepared under the authority of and in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et. seq.) and are consistent with the intent of the National Environmental Policy Act of 1969.

Sincerely,

Richard F. Berry

Richard F. Berry
Field Office Supervisor

cc: Minn. DNR, St. Paul
S. Bittner, Gulf South Res. Inst., New Iberia

U.S. Army Corps of Engineers

North Central Division

Comments on the

Draft Snake River Subbasin Report

June 1980

Cmt. No.	Page & Para.	Comment
1.	Page 8	Figure II is a poor map cartographically. Include a legend which clearly describes the patterning used to delineate the 100-year floodplain, marshy areas, etc.
2.		Suggest modifying the explanation of nonstructural measures. Include the following: "Nonstructural measures modify the susceptibility of land, people, and property to damage or losses. In addition, they modify the impact of flooding upon people and communities. Nonstructural measures do not attempt to modify the behavior of floodwaters."
3.	Page 54	Add a discussion of the National Objectives (NED & EQ) as established by P & S.
4.	Page 55	The list of objectives is basically good, but awkwardly written. Would suggest rewriting as follows: "Enhance the recreational opportunities in the Snake River subbasin for the benefit of the local people".
5.	Pages 58-62	The alternatives being evaluated are a series of four channel improvements. Three of these alternatives are described in number 2 on page 58; however, in Table 15 on page 62 these alternatives are separated and treated individually. Recommend each alternative on page 58 be described and discussed individually.
6.	Pages 61 66	Assessment and evaluation sections need to emphasize how each alternative meets or doesn't meet each objective, both study objectives and National Objectives.
7.		The discussion of irrigation appears to assume uncontrolled development. Is this the case? Doesn't the State regulate well drilling? Also, is there any study which discusses groundwater usage and depletion in the area? Clarify.
8.		Holding a public meeting in 1971 does not necessarily mean that either the Corps has good understanding of the locals' needs or the public correctly perceives the Corps' activitie Clarify.

SUBJECT: Comments on the Draft Snake River Subbasin Report June 1980

Cmt. No.	Page & Para.	Comment
9.	Page 66	Additional study is warranted, provided that the economics are valid. The cost estimates for the projects should be provided. Also the benefit analysis should be shown. The costs, benefits, and B/C ratio should be presented on page 66, paragraph 8, Evaluation.
10.	Page 67	Additional specific planning objectives should be developed, if this subbasin is included in the Red River of the North Reconnaissance Report. These objectives should address important resources to be preserved and/or enhanced as a result of the additional study needs (pps. 67-69). Additional objectives should address the problems and needs identified in this report, including the preservation of the remaining prairies, woodlands, riparian vegetation (including Alvarado Woods), cultural resources, and improvements in recreation (hunting, camping, fishing, swimming, and hiking).
11.	Page 69	"Additional Studies needed", comment 18. From a hydrologic-hydraulic standpoint the need for adequate studies to answer this question cannot be understated. This should include impacts on discharge-frequency relationships due to levee or channel work.

STATE OF MINNESOTA
DEPARTMENT OF NATURAL RESOURCES
444 Lafayette Road, Space Center Bldg., St. Paul, MN 55101
PHONE 612/296-4800

July 7, 1980

Colonel William W. Badger
St. Paul District Engineer
Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, MN 55101

Dear Colonel Badger:

COMMENTS ON SAND HILL AND SNAKE RIVER SUBBASIN REPORTS

The Department of Natural Resources, Division of Waters, has reviewed the above referenced documents. Many of the comments that were submitted for previous subbasin reports are pertinent to these documents as well. I hope that the contractor will keep this in mind.

As I stated in my last letter, I realize that it is difficult to analyze proposals when one is forced to use secondary data or no data at all. The main problem is that many of the innovative proposals such as extensive land treatment, floodwater storage in drainage ditches, relocation/aquisition, floodproofing and other non-structural measures are possibly the only alternatives available in some areas, and there is absolutely no data to indicate how feasible these alternatives might be. The only alternatives that are being evaluated are adapted from previous studies or from studies in nearby watersheds. If anything is to come out of this Reconnaisance Study, information is needed on the feasibility of some of these other alternatives. If this is not possible, maybe an assessment could be made on the cost of collecting some of the data that appears to be needed over most of the basin.

With regard to the Snake River Subbasin Report, five economically feasible alternatives are identified on page 62. Either some of these alternatives overlap or else many of the benefits claimed are related to improvements other than flood damage reduction. Average annual damages over the project period are only $474,000 for the whole basin but a total of more than $1,400,000 in average annual benefits are claimed for these measures. More information is needed on how these benefits were derived.

Again, I hope the contractor will utilize these comments and the comments submitted for other subbasins as modifications are made in these documents. If you have further questions please contact Joe Gibson at 296-0438 or Ron Harnack at 296-0440.

Sincerely,

DIVISION OF WATERS

Larry Seymour
Director

LS/JG:ph

cc: Joe Gibson
Ron Harnack

MIDDLE RIVER - SNAKE RIVER
WATERSHED DISTRICT
122 w. johnson avenue
telephone 218/745-4741
warren, minnesota 5676

June 25, 1980

Department of the Army
St. Paul Corps of Engineers
1135 U.S. Post Office
St. Paul, MN 55101

ATTN: NCSED-PB

RE: Subbasin Report for the Snake River Watershed, June 1980.

Dear Colonel Badger:

I have reviewed the above described report prepared by Gulf South Research Institute. In the interest of having this report as accurate as practical, I aave prepared the following list of comments for your consideration.

Ref #	Page	Paragraph	Comments:
*1	3	1	The drainage area of the Snake River at the outlet excluding the Middle River is approximately 464 square miles and including the Middle River is approximately 759 square miles.
*2	3	2	The lowest point in the Basin is at approximately 785 ft MSL and the highest point is at approximately 1165 feet MSL for a difference of 380 feet.
*3	3	3	The drainage area of the Snake River is approximately 486,000 acres including the Middle River Basin. The Middle River outlets into the Snake River approximately 10 river miles above the Red River.
4	4	Figure I	The Drainage divide is incorrect and Polk County is shown to include Pennington County.
5	8	Figure II	Figure II does not present a reasonable facsmile of the flood hazard for the Snake River and is not suitable for even general planning.

Ref #	Page	Paragraph	Comments:
6	10	3	The figure $140,000 used as urban damages is obviously in error.
7	11	Table 1	Table 1 shows $14,000 as the 1979 Public damages. The city of Warren received approximately $42,000 from FDAA for 1979 flood damages and estimates by the city put the total damages in Warren between $750,000 to $1,000,000 in 1979. The figures used in Table I should be checked for their validity as they appear to grossly misrepresent the damages sustained.
6	12	3	Most of the prairie and wetlands in the subbasin as they existed prior to about 1890 have been converted to an agricultual use. The growth of substantial areas of woodlands outside of the river corridor occured after settlement.
*9	13	1	The 95 acre Alvarado Wildlife Management Area was initially proposed to be acquired by the state by residents in the vicinity of Alvarado, Minnesota. The state has acquired this property.
10	13	4	There are no substantial waterfowl production areas in the subbasin.
*11	29	1	The Snake River channel in the vicinity of the mouth is not an artificially constructed channel; of the approximately 85 miles of Snake River Channel approximately 2.6 miles is an artifically constructed channel. (River Mile 34.5 to 37.1)
12	29	2	There is no basis for the conclusion that channel improvements have affected the fishery resources of the Snake River.
*13	30	Table 6	Tabel 6 does not include Pennington County which includes a portion of the Snake River Basin, nor is this table relevant to the discussion on page 29 because apparently none of the lakes listed are within the Basin.
14	34	3	The Rosewood Area is in the Snake River Drainage Basin and is a
15	35	Figure 6	proposed Wildlife Management Area.
*16	37	3	Substantially less than 1.6% of the Basin is water areas.
17	38	Table 9	County percentages of Woodland are not representative of the Snake River Basin. The figures provided are misleading when applied to the Snake River Basin.
18	39	Table 10	The area of Wetlands in Polk County has little or no relation to
	40	Table 11	the wetland area in the Snake River Basin.

Ref #	Page	Paragraph	Comments:
19	50	2	Figure 4 and Paragraph 2 are contradictory.
20	51	Figure 4	
21	52	2	No mention is made of existing flood plain zoning ordinances.
22	52	3	The idea that floods may be controlled in the Snake River Basin by the storage of waters in artifically constructed channels is obviously not a feasible flood alternative.
23	53	1	The conclusion that the cleared portions of the Snake River functions satisfactorily is not consistent with the regional flood plain map (Figure II). A flood plain width of 8 miles does not support your conclusions that the channel functions satisfactorily.

The above listing contains my comments which are based upon my knowledge of the Snake River Basin. This list is not intended to alter the information in the report but to make it a more reliable source of information. I trust you will give these comments consideration in your redraft.

Sincerely,

Ronald J. Adrian
Engineer MRSRWD

RJA:og

GENERAL COMMENTS
DRAFT SNAKE RIVER SUBBASIN REPORT
(JUNE 1980)

(These comments apply to the entire report and all subsequent subbasin documents.)

1. This document generally needs additional detailed information concerning nonstructural alternatives. Few of the structural alternatives appear feasible; therefore, unless economics are ignored, nonstructural solutions remain important to reduce the magnitude of future flood damages. The overall report should address and clarify this aspect of flood damage reduction planning.

2. Comments from Federal, State, and local agencies and a letter from the St. Paul District will be included in an appendix in each final subbasin and in the overall report. The format for the appendix will be:

a. Introduction - This section should stress:

(1) The importance of completing the study on time.

(2) That the purpose of the study is to advise other agencies and interests.

(3) The need for a selected review by various interests to provide complete and factual documentation.

(4) The use of the study as a building block for future water resource efforts.

(5) That cooperative efforts to evaluate results and develop solutions to remaining problems will be incorporated.

(6) A complete public involvement program when the study is finished.

b. The distribution list.

c. Copies of letters of comment.

Only comments that identify significant errors or need specific attention will be addressed in the final subbasin report. However, all comments incorporated should be identified with a marking system. The distribution list for the final Snake River subbasin report is given below:

Agencies receiving draft report	Date sent	Date comments received
Federal		
Soil Conservation Service	9 Jun 80	20 Jun 80
Fish and Wildlife Service	12 Jun 80	10 Jul 80
Corps of Engineers, North Central Div.	9 Jun 80	3 Jul 80
Corps of Engineers, St. Paul District	9 Jun 80	20 Jun 80

Incl 2

State

Water Planning Board	12 Jun 80	-
Department of Natural Resources	9 Jun 80	7 Jul 80
Planning Agency	12 Jun 80	-
Water Resources Board	12 Jun 80	-

Local

Watershed District	12 Jun 80	25 Jun 80
City of Alvarado	12 Jun 80	-
Northwest Regional Development Commission	12 Jun 80	-

3. The source for most information identified in the majority of the tables is Gulf South Research Institute. If other sources were used, an appropriate reference should be made.

4. The evaluation section of each report is primarily the recommendations of the document. Generally only the structural alternatives which have a benefit-cost ratio greater than 1 are presented. Little attention is given to the other structural and nonstructural alternatives that may be an important aspect of future flood damage reduction planning for the subbasin and basin as a whole. Therefore, it is recommended that this section be expanded to provide the appropriate discussions.

5. Rather than stating in each report and for each alternative evaluated that there will be little or no effect on cultural resources, the report should indicate that it is not possible to identify effects on cultural resources until a systematic cultural resources survey has been completed in the subbasin. Such statements are misleading since it appears that there are no significant sites in the subbasin. In reality, there are simply no known sites.

6. The supporting information for alternatives, including technical, economic, and any environmental data, should be provided (at least under separate cover). This would simplify matters when questions are asked during review or in the future.

7. The maps should have more detail. Often information in the text is not clearly illustrated in the maps.

8. Almost all of the subbasin documents identify significant water resource problems (i.e., flooding, water supply, water quality, etc.) throughout the subbasin. However, little if any, reduction in flood damages can be expected from the implementation of the economically feasible alternatives. As a result, the overall document is very important if it is to be valuable to the residents of the basin and if it is to serve as a guide for all Federal and State agencies. This document cannot be a reiteration of the subbasin report.

9. The St. Paul District. Corps of Engineers, will soon initiate a Section 205 reconnaissance study for flood control at Alvarado.

10. In the bibliography all references from the same source during the same year should be listed alphabetically so that those references can be distinguished. References to the U.S. Army Corps of Engineers need clarification throughout the report. These references should be standardized to read "St. Paul District, Corps of Engineers."

St. Paul District, Corps of Engineers
Specific Comments on the
Snake River Subbasin Draft Report
(June 1980)

*1. Page 3, paragraph 3 - Do the entire 402,560 acres drain into the Snake River or does some of the area drain into tributaries of the Snake River or the Red River of the North?

*2. Page 4 - Pennington County is not shown on this map or other maps in the report.

3. Page 7, paragraph 3 - One reason the peak flow from the Snake River coincides with the peak flow on the Red River is the duration of the Red River's peak in this area. Although the Snake River does not seem to contribute significantly to the peak flow on the Red River, its backwater, being in such a flat basin, may affect the flooding.

*4. Page 7, paragraph 1, Location and Extent Section - The second sentence is not correct. The U.S. Geological Survey maps of flood-prone areas and flood insurance maps (although incomplete) do provide a general delineation of flood-prone areas.

5. Page 10, paragraph 1 - The Snake River Section 205 Study done by the Corps of Engineers gives figures of 82 percent for the rural portion of the average annual damage figure and 19 percent for the urban damage.

*6. Page 13, Environmental Concerns, last paragraph - "...affect on aquatic biota...", should read "...effect on aquatic biota...".

7. Page 13, Recreation Problems, paragraph 1 - Some statement on demand should be included. If recreation demand is low, then there is not a problem.

8. Page 14, Recreation Problems, paragraph 1 - (must travel outside the subbasin..). The subbasin is not a geographic boundary. Distance would be the main constraint, and discussion of distance would be more meaningful.

*9. Page 14, Water Supply Problems, paragraph 1, 1st sentence - This should read, "...upland till in the eastern portion."

*10. Page 16, Irrigation, paragraph 1 - In 1971, there was no irrigated land in Marshall County. Please explain where the 80-acre figure originated.

11. Page 16, Irrigation, paragraph 1 - This paragraph is unclear in that it states that the subbasin's soils are only moderately suited to irrigation activities and that flooding problems lowering farm income is the chief factor in irrigation systems not being installed by farmers. The paragraph should be rewritten to give the reader a clearer understanding of the problem. Additional information that supports the assumption would also be helpful.

*12. Page 16, Wastewater Management, paragraph 1 - The discussion of the waste treatment at Warren is not clear. Perhaps the word "efficiently" should be changed to "inefficiently," in the fourth sentence of the paragraph.

*13. Page 18, Hydropower - Minneapolis and St. Paul are southeast, not southwest, of the Red River basin.

14. Page 18, Public Perception, paragraph 1 - This entire section contains statements and assumptions that may be a little too strong, considering the data that are available to support them. Some qualifications should be included concerning the sources of these data. Making assumptions based on these reports is different from reporting the assumptions made by other groups in their reports. Unless further data are documented, strong statements about public perceptions should not be made.

*15. Page 18, Public Perception, paragraph 4 - There was partial snagging and clearing of 23 river miles from the mouth to within 10 miles of Alvarado. This was done with flood emergency funds by the Corps following the 1969 flood. Also, there have been local agricultural and ring levees built in the subbasin.

*16. Page 20, Social Characteristics, paragraph 1 - It is unclear if in- and out-migration are in fact net migration. If they are not, then net migration should be noted. Also, do the figures include seasonal or migrant workers? The first sentence refers to a "steady decline in population," yet population growth is mentioned in following sentences creating some inconsistencies. Please clarify.

*17. Page 20, Social Characteristics, paragraph 2 - In what year was Warren's population 2,035?

*18. Page 20, Social Characteristics, paragraph 4 - What is meant by "close-knit community"? Since this is an ambiguous term, an explanation would help.

19. Social Characteristics Section - This section could be confusing to some readers and should be rewritten. Put percentage figures in a table where they can be more easily compared, rather than in the text. Also, the mix of information from counties and communities is somewhat confusing; a better organization of this mix might increase clarity.

20. Page 21, Employment Characteristics, paragraph 1 - In a small population area only a few can constitute a large percentage. Should the percentages be accompanied by the numerical figure? Tables also would help present the material in this section.

21. Page 22, Income - Include percentage of increase in income from 1969 to 1977. Also, include income distribution such as percentage below poverty level.

22. Page 22, Agriculture Section - In addition to the factors noted on yield per acre, harvested acres, and total production for particular crops, it would be helpful if gross income per acre for particular crops was included. This information would give a better understanding of the relative importance of each crop. One other factor that would aid understanding of flooding problems is the differential susceptibilities of crops to flood damages. Some crops are not as seriously affected by a flood event as others. In addition, the differential costs per acre to plant particular crops would aid understanding.

* 23. Page 22, Agriculture, paragraph 1 - For being an approximate percentage, 313,997 acres is an accurate figure.

* 24. Page 24 - More descriptive column headings are needed in tables 4 and 5. It should be noted that total production in table 4 is in bushels. In table 5, what does SIC and "estimated employment" mean? What is "estimated employment"? Is the 44 a percentage? Total employment is 2,865.

* 25. Page 25, Transportation Network, last paragraph - Either an area is, or is not, subject to flooding. Rephrase, "...may be subject to flooding."

26. Page 25, Land Use, paragraph 1 - 78 + 10.9 + 8 + 1.8 = 98.7 percent. What is the remaining 1.3 percent?

* 27. Page 26, Climate, paragraph 1 - The cities of Thief River Falls and Crookston have weather stations which are outside the subbasin but not far away.

28. Page 27, paragraph 1 - One of the wetland zones identified is the glacial lake Agassiz beachlines. The beachlines are gravel ridges and not indicative of wetland areas. Presumably, the wetlands occur between the beachlines. This should be clarified. Radium is mentioned as a reference point in this paragraph. It would be useful to include this point on the maps in the report.

* 29. Page 28, paragraph 1 - "Wetlands afford spawning..."; not spawing.

30. Page 31, Water Quality, paragraph 1 - Big Woods is mentioned as a reference point. This point is not shown on the maps and should be included.

31. Page 33, Cultural Elements - The quality of maps would be improved if the subbasin was outlined against township and section lines. It is difficult to check site locations on the basis of the present maps.

* 32. Page 34, Recreational Resources, paragraph 1 - Severely is misspelled.

33. Page 36, Social - In addition to the information presented, a discussion of the social consequences or implications of flood events should be presented, particularly those concerning behavioral damages that may occur.

* 34. Page 41, Threatened or Endangered Species - The arctic peregrine falcon has been extirpated from Minnesota since the early 1960's. The subbasin does lie within the migratory route of the peregrine falcon and sightings may occur. The wintering range of the species is south of the subbasin. The Dakota skipper butterfly should be mentioned as a proposed endangered species.

* 35. Page 42, paragraph 1 - All the species named are reptiles. Since the general reader may not know what a herpetile is, it is suggested that the word "reptile" be used.

36. Page 43, paragraph 1 - Is "most probable" synonymous with "with project" conditions?

37. Page 43, Economic Conditions, paragraph 2 - Why was Warren designated as a potential growth center by the Northwest Regional Development Commission?

38. Page 46 - On the flood damages chart, are Warren and Alvarado switched? It would seem that Warren would have higher urban damages because of a larger population and lack of a municipal levee.

39. Page 47, Environmental Conditions, paragraph 1 - Are there, in fact, plans to implement adequate treatment procedures so that this would be the most probable condition?

Paragraph 2 - Why are woodland habitats expected to gradually increase? Some supporting evidence would be helpful.

* 40. Page 49, Institutions, paragraph 3 - Other completed flood control projects include agricultural levees and some ring levees.

* 41. Page 52, top paragraph - In the last sentence, the wording is bad. "The county that the subbasin is in..."? There are portions of three counties in the subbasin.

* 42. Page 52, paragraph 1 - Does Alvarado have a floodplain ordinance and a building code for floodplain areas?

* 43. Page 53 - "Less frequent floods" and "frequent floods" are referred to, but the reader is left with little understanding of what is meant by these terms. Also, aggravate is misspelled.

* 44. Page 54, Floodplain Management, paragraph 3 - The second sentence in paragraph 3 should read "Tangible economic benefits or appropriate gains in environmental quality must exceed overall costs."

* 45. Page 54, Planning Objectives - The second paragraph should be changed to read:

> The development of planning objectives involved a broad-range analysis of the needs, opportunities, concerns, and constraints of the subbasin from the information that was available. On the basis of this analysis of the problems, needs, and desires that could be identified, the following planning objectives were established.

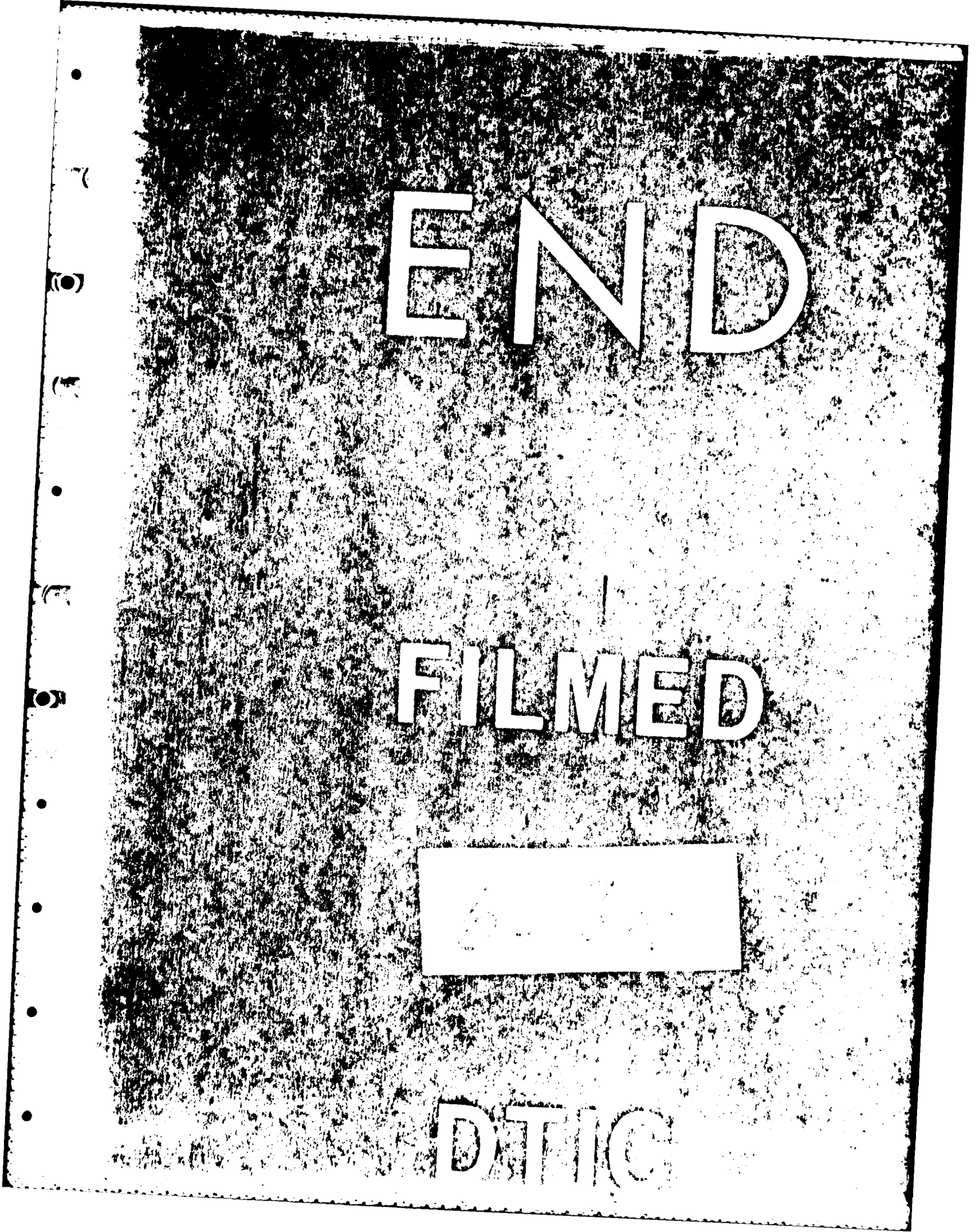
*46. Page 61, Assessment of Alternatives Section - Pages 33, 34 and 36 discuss the presence of archeological sites along the Snake River and in the subbasin and the lack of historical site investigations. Therefore, the determinations of "no" or "negligible" effects on cultural elements given in this section should be given as "unknown effects."

*47. Page 63, Channel Improvements, paragraph 1 - A maximum beneficial level of biological and water quality effects is a questionable result of channel improvements. Several negative impacts may result from channel improvements. These include possible higher peak flows and lower low flows, possible reductions in wildlife populations because of removal of streamside vegetation, and possible higher than normal levels of sediment discharge as the stream channel adjusts to new flows. The text of this paragraph should reflect these possible negative impacts.

48. Page 63, Channel Improvements, paragraph 3 - Beneficial recreational features attributable to channel improvements are questionable. Improved water quality is not always a result of this type of development, although it can be improved by incorporating fish and wildlife structures. However, the associated costs are likely to be prohibitive. Only under certain conditions can recreational benefits be anticipated.

49. Page 65, Farmstead Levees - It is questionable in this situation as to whether or not the use of borrow pits for fishing purposes is a reasonable recreation benefit resulting from the construction of agricultural levees. Borrow pits used for this purpose would require some level of fisheries management to be successful. The costs associated with these actions are probably prohibitive in this situation, because of the low population density in this area. Therefore, it should not be considered as a recreation benefit.

50. Page 68, Nos. 12 and 13 - A detailed social profile, institutional analysis and social impact assessment are already being prepared by the Corps of Engineers for this subbasin. It should be noted in each subbasin report that the probability of institutional and social boundaries being the same as subbasin boundaries is remote at best. Since this boundary overlap exists, integrated basin-wide social and institutional analysis is desirable.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